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By- Allen, William H.; And Others
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An experiment comparing the pedagogical effectiveness of five different modes of audio narration in motion and still pictures showed only small differences in sixth graders' learning. Ten experimental groups were formed in which the 351 subjects viewed motion pictures and still slides accompanied by supplementary, redundant, directive, question-posing, and nonlinear narration. The posttest-only experimental design specified no control group. Two weeks after the experiment a composite intellectual ability test was administered in hopes of using the scores from it with the data from the experiment to improve predictions of performance for audiovisual materials. No differences in total amount of learning were revealed for the entire group, for either audio or visual variables. Analysis revealed that students in the low mental ability group scored lowest on presentations that posed questions and that high ability students performed best on treatments with supplementary narration and poorest on question-posing treatments. Only on the knowledge portion of the posttest were there significant differences in learning, favoring the directive, redundant, and supplementary audio styles. A qualitative analysis using the semantic differential showed that motion pictures were more positively received than still pictures. (OH)

Final Report

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AUDIO IMPLEMENTATION OF STILL AND MOTION PICTURES

William H. Allen

Stuart M. Cooney

Royd Weintraub

University of Southern California
Los Angeles, California

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SUMMARY

Two sets of variables were investigated in this study: modes of implementing the audio narration and modes of presenting the visual stimuli.

Objectives

The purpose of the study was to compare the effectiveness of an audiovisual instructional communication in sixth-grade general science under the following conditions:

1. By five different methods of presenting the audio narration with each visual presentation mode: supplementary sound, redundant sound, directive sound, question-posing sound, and non-linear sound.

2. By two different methods of visual presentation with each audio implementation mode: motion picture film and still slides.

3. For learners with different mental ability and vocabulary achievement characteristics.

Procedure

A basic instructional motion picture was produced on the subject of "Oceanography" and combined with five different styles of audio narration. Each of the five sound films was also converted into sound still slide versions by sampling the motion picture sequences at appropriate points. A total of 351 sixth-grade students were assigned at random to the ten experimental treatments, constituting a 2 x 5 factorial design (visual presentation x audio implementation). Subjects were tested immediately after presentation of the stimulus treatments on a 67-item performance test of knowledge, comprehension and application. A semantic differential scale was used to obtain qualitative measures of student reactions to the stimulus material. Analysis of results was by analysis of covariance, factor analysis, correlation analysis, and t-test comparisons.

Results and Conclusions

The results and conclusions are summarized for the major comparisons, the learner characteristics, and the qualitative reactions:

1. There were no significant differences in learning for the total population among the audio implementation or visual presentation variables.

2. Subjects with lower mental ability performed the poorest on audio treatments that posed questions to be answered or presented the audio in a non-linear way.

3. Subjects with higher vocabulary achievement performed best on audio treatments that presented the audio in a conventional augmented way and poorest on the question-posing and non-linear styles.

4. Only on the knowledge subtest were there significant differences in learning, favoring the direction, redundant and supplementary audio styles.

5. The qualitative analyses indicated that the motion picture groups perceived the sound films more positively than the still slide groups perceived the sound slides. The motion picture films were rated as being more active and the still slides as less active.

6. In summary, the study revealed little difference in learning from motion picture films or still slides when implemented with different styles of audio narration. Students of lower mental ability appeared to be deterred in their learning by narrations that asked questions or presented the narration in a non-linear way, and these audio implementation styles seemed to more directly influence the acquisition of knowledge than the comprehension or application of the knowledge. There appeared, however, to be no direct relationship between performance on the test and affective rating of the instructional communication.

CHAPTER I

INTRODUCTION

Fundamental to effective use of educational media is the design of the messages that pass through them. Variations in message design, in combination with available media and known characteristics of learners, create a complex pattern of interacting relationships. This study was part of a comprehensive search for invariants in this pattern of relationships. Such stable factors, once identified, will become the empirical basis for the systematic development of principles of message design.

The Problem

This study had as its purpose the investigation of the effectiveness of five different modes of audio narration in combination with motion picture and still picture presentations. The audio modes selected for study represented conventional and experimental techniques for implementing the visuals in instructional films, sound filmstrips, or television presentations. The study of these audio modes in combination with both motion and still modes of visual presentation permitted a determination of possible interactions between audio and visual design factors. Each audio-visual variable was also studied in relation to selected learner characteristics.

In particular, a general science film on the subject of "Oceanography" was designed for presentation to randomly assigned sixth-grade students. The audio sound track of the film was modified to be presented in five different audio implementation modes, characterized in this study as Supplementary, Redundant, Directive, Question-Posing, and Non-Linear sound. Each of these five sound motion picture film versions was also converted into sound still slide versions. In all, this comprised a total of ten experimental treatments constituting a 2 x 5 factorial design. Effects of the treatments were measured by instruments specially developed for the experiment.

The study had as its major objective the determination of the effects of audio implementation in combination with motion picture and still picture presentation. The specific objectives studied were:

1. To determine the comparative effects of five kinds of audio implementation upon the learning of factual information presented by motion picture and still slides.

2. To determine the comparative effects of motion picture and still slide presentation modes when implemented by different kinds of audio narration.

3. To determine the interactions of five different kinds of audio implementation with motion picture and still slide presentation modes.

4. To determine the relationships between the various stimulus modes and specified learner characteristics (mental ability and vocabulary achievement).

5. To determine the effects of the various stimulus modes upon subtest questions measuring knowledge, comprehension, or application of learning.

6. To examine the attitudinal or qualitative data that might indicate the learners' condition or reactions during the experiment.

Review of Related Research

There is a dearth of previous experimental research bearing directly on the major problem being studied: the relative effectiveness of different modes of audio narration and their relationships to the mode of visual presentation. The study of this specific problem has thus far been neglected, the principal research effort being directed to comparisons of the overall effectiveness of the audio, visual, and print modes, either singly or in combination (Hartman, 1961). Yet the need for a more complete identification of the specific audio variables and their relationships to the pictorial characteristics of educational media is apparent if a science of instructional message design is to be evolved. The research bearing on this problem will be reviewed in two sections, each treating a different class of variables: type of audio implementation and type of visual presentation.

Audio Implementation

Of the five types of audio implementation being studied, only "Question-Posing" and "Directive" sound have received direct research attention. However, as there is some related instructional media research that has an indirect bearing on several of the other audio modes, the research relating to each of the five types of audio being studied will be reviewed.

Supplementary. This technique of audio narration is nearest to the "conventional" mode of instructional film commentary, wherein the sound track partially supports the visual and partially expands on it with additional information not visually depicted. Thus the possibility of interference between the channels is increased, as suggested by Travers (1964, 1967). However, such interference may occur only when information is presented at a high rate of speed; information presented at a low rate of speed may permit the receiver to switch back and forth between channels without detriment to the learning of the information presented in either channel. In the present study, the still slide visual presentation modes should give greater opportunity for this receiver to switch between visual and audio channels than would be the case with the motion picture visual presentation modes. Davis (1965) studied the effects of superimposing supplemental information on an instructional film. He found that the supplemented audio information did interfere with the learning of the visual information over which it was superimposed; but that, in turn, the audio superimposition itself presented additional information which increased the overall learning from the audiovisual presentation. The net result was that there were no significant differences in learning among the audio, visual and audio-visual presentations.

Redundant. This audio technique has not been studied as a discrete variable except under strictly controlled laboratory conditions where the audio and the visual presentations were made simultaneously. Under these conditions, there appeared to be no advantage to two-channel presentation over single-channel presentation (van Mondfrans and Travers, 1965; Travers, 1967; Severin, 1967). However, evidence was presented by Hartman (1961) and Nelson and Moll (1950) that learning is facilitated when redundant information is presented in both audio and visual channels in normal instructional communications. As was the case in discussing Supplementary sound above, the questions of rate of presentation and the nature of the precise simultaneity of the two channels have bearing on the conclusions. Carpenter's (1953) "sign similarity hypothesis" would suggest that similar visuals and words would be mutually reinforcing. In actuality, pure "redundant" sound (literal verbal translation of the visual) is seldom, if ever, encountered, but is usually combined with "supplementary" sound.

Directive. Although there is no extensive body of research evidence on the use of audio narration to "direct" the learner to attend to specified visual cues, Hoban and van Ormer (1950), Allen (1960), and Lumsdaine (1963) all cited studies indicating the effectiveness of some form of attention-direction prior to the instructional presentation. Zuckerman (1949) found, with a military population, that directive statements in the film commentary were more effective in promoting motor skill learning than third person passive-type statements, but Allen (1952) found that the use of imperative sentences in the narration was no more effective in promoting learning than the use of questions and of personal words and sentences.

Question-Posing. Lumsdaine and others (1958) showed that the instructional effectiveness of a film could be increased by splicing in "thought-provoking" questions designed to stimulate curiosity. However, in another study with fifth-grade pupils, Lumsdaine (1958) found only a slight tendency for improvement through the use of rhetorical questions in the narration. Kantor (1960) found no increase in learning when he inserted questions (both aurally and visually) into the content of a seventh-grade science film, and Vuke (1962) also inserted questions aurally in a general science film with the same result.

Non-Linear. No known research evidence is available on the use of sound in a subjective, personal, varied way. Related evidence supports the contention, however, that subjective involvement may induce learning. Allen (1960) reported a number of media studies showing that certain involvement factors influenced audience reactions to films. It is noteworthy that one of the most powerful devices used by novelists to gain reader attention is the subjective or "stream of consciousness" technique. Cooney and Allen (1964), studying the non-linear variable in filmic presentation, raised a number of issues relative to the non-linear aspects of sound and picture.

Visual Presentation

In extensive reviews of the research comparing the effectiveness of motion picture with still picture presentation, both Hoban and van Ormer (1950) and Allen (1960) concluded that no apparent instructional advantage existed for either of the modes. No research attention, however, has been given to the relationships of varied audio implementation techniques to alternate motion and still presentations.

CHAPTER II

METHOD AND PROCEDURES

Controlled experimentation was used to assess the combined effects of the audio implementation and visual presentation variables upon learning. Multiple treatments of stimulus motion picture films and slides were presented to randomly selected groups of sixth-grade elementary school students. Multivariate analysis was used to compare effects and to relate these effects to characteristics of the learners.

Experimental Design and Method

Experimental Design

The design of the study called for the development of the ten experimental treatments described below, the administration of these treatments to experimental subjects under controlled conditions, the testing of performance of the subjects by means of a posttest given immediately following exposure to the stimulus material, and the comparison of the performance data by means of appropriate statistical techniques. The subject matter of the stimulus film and slides was "Oceanography," a subject not included in the normal sixth-grade curriculum yet comprehensible to that age group. Subjects were 351 sixth-grade students from the Pasadena Unified School District (California), assigned at random to the different experimental treatments.

Comparisons of the performance data were made by analysis of covariance technique for the audio implementation methods, the visual presentation methods, and the interactions between the two methods, constituting a 5 x 2 factorial design. These comparisons were made for the total groups, for high and low mental ability groups, for high and low vocabulary groups, and for the total groups on each of the three subtests (knowledge, comprehension, and application items). In addition, qualitative reactions of the subjects to the treatment modes were compared.

A posttest-only design without a control group was used, because the study was testing hypotheses concerning which of several treatments produced the greater effects and was not concerned with the question of whether the treatments were more effective than no treatment at all.

Experimental Variables

Audio implementation modes. Five different methods of presenting the narration on the audio sound track were designed for presentation with both the motion picture and the still slide material:

1. Supplementary sound, in which the sound track partially supported the content shown in the visual presentations and partially expanded on it with additional information not visually depicted. This type of narration characterizes the "conventional" mode of instructional film or sound filmstrip commentary. It might be predicted that such audio narration would result in interference with information presented in the visual channel, but teach other information not contained in the visuals.

2. Redundant sound, in which the content appearing in the visuals was described literally and simultaneously in the audio narration. It might be predicted that the one-to-one correspondence between the verbalization on the sound track and the specific content of the visual would lead to a "summation of cues" and a consequent facilitation in learning of the materials presented or that the simultaneous nature of the visual/audio presentation would lead to channel interference and reduce the learning.

3. Directive sound, in which the audio narration directed attention to or pointed out relevant cues in the visual materials for emphasis and special consideration. It might be predicted that such a technique would focus attention so that the learner would respond only to the relevant cues in the visual and not be misled or distracted by the irrelevant ones.

4. Question-posing sound, in which questions were raised relative to the visual content with the intent of accenting the visual cues to be learned. It might be predicted that the requirements to covertly answer questions related to visual material while the visuals were being exposed would cause learners to participate more actively in the communication and thus increase their learning of that material. On the other hand, such questions might cause the learner to be thinking about answers to the questions asked as the communication presented other material to be learned, thus interfering with learning.

5. Non-linear sound, in which the audio narration was presented in a more subjective style, varying in pace, using incomplete sentences, "bunching" a flow of impressions. It might be predicted that this style of narration would obtain audience involvement and enhance the learner's "feelings about" the content, but that it might not necessarily enhance the learning of specific information.

Visual presentation modes. Two different visual modes of presenting the content were used with each of the five audio implementation modes:

1. Motion picture film, in which the visual stimuli were presented as live and animated motion picture photography projected on the screen. Such visuals were representative of the kinds of pictorial illustrations appearing in instructional motion pictures and televised instruction.

2. Still slides, in which the visual stimuli were presented as still pictures projected on the screen. These still pictures were selected and copied from the motion picture film so as to present the concepts being presented and tested. Such visuals were representative of the kinds of pictorial illustrations appearing in filmstrips, slides, and televised instruction.

The audio implementation and visual presentation variables were combined to produce the following ten experimental treatments: Supplementary Motion Picture, Redundant Motion Picture, Directive Motion Picture, Question-Posing Motion Picture, Non-Linear Motion Picture, Supplementary Slide, Redundant Slide, Directive Slide, Question-Posing Slide, and Non-Linear Slide.

Experimental Population

The total experimental population consisted of 351 sixth-grade students drawn from five elementary schools in the Pasadena Unified School District (California). The subjects used comprised the total sixth-grade population of these schools. Subjects having a reading ability under the middle of the fourth-grade were eliminated from the study. An additional group of about 100 sixth-grade students from another Pasadena elementary school provided subjects for the two tryouts of the performance test and preliminary versions of the stimulus film.

A rotational scheme was devised for assigning segments of each school to one of the ten groups. This device was necessitated by variations in the socioeconomic levels of the schools and the need to equalize this factor among all the experimental groups. Using a table of random numbers, subjects were then assigned at random to each segment, comprising part of a treatment group. The employment of the analysis of covariance technique was a further control to assure homogeneity of the different experimental groups.

Development of the Experimental Stimulus Materials

The films and slides used in the experiment met several stringent requirements: their content had to be understandable by the subjects, yet provide sufficiently novel information to minimize effects of prior knowledge and to permit development of a range of test items;

the visual elements had to be readily available either from existing films or through use of art work in simple animation.

Subject Matter

Curriculum guides used in the school district were studied in search of content that would meet these criteria. The resulting list—which included various aspects of perception, meteorology, information processing and transmission, navigation, and oceanography among its 28 possibilities—was shown to several sixth-grade science teachers. Each independently selected oceanography, and two heads of science departments placed particular emphasis upon physical oceanography.

Several meetings followed with Dr. H. Bradner and his staff at the Scripps Institute of Oceanography in La Jolla, California. During these conferences, the topics possible in physical oceanography were narrowed to the physical attributes of ocean ecology: in particular, light, temperature, and pressure. Later script development reduced these to light and temperature.

Experimental Materials Production

The experimental stimulus materials (see Appendix A) were adaptations of an experimental film developed for a companion study, "Learner Response, Feedback, and Review of Film Presentation" (Allen and others, 1968). The experimental film used from that study was a version called the "Expository No Response" treatment, and it served also as the "Supplementary Motion Picture" treatment in this study. The procedures followed in the production of the experimental films in the earlier companion study are detailed immediately below.

A large number of existing instructional films and a great deal of undersea research footage was surveyed for materials that would fit the requirements of the study. Relevant materials were obtained for duplication and combined with original animated art work and original live footage photographed especially for the experiment.

The film was edited in several stages. A rough cut was made to organize the collected and specially prepared footage. After review on a picture-sound interlocked projector, and after consequent major modifications had been made, finer cuts were undertaken to fit a preliminary narration. No optical effects, such as fades, dissolves, etc., were used in the film. The resulting film was then pretested with students in a Pasadena elementary school. Analysis of test items, data from interviews with students, and observations by the staff all provided a basis for further modifications in the narration and visual material of the film. The revised film and test items were then tried out again, and again changes were made to develop or to simplify concepts found to be difficult by the subjects. For example, it was found that the subjects did not understand the relationship between the production of chemicals by bacteria at the bottom of the sea and the chemical feeding of plants at the surface. By animating the pattern of flow between these two levels, the concept was clarified.

With the narration for the Supplementary Motion Picture version completed, the remaining four narrations were written and revised several times in order to conform to the requirements of each of the audio implementation variables. All five of these narrations are presented in Appendix A.

The appropriate footage from the motion picture films were then fitted to the narrations, checked on an interlocked projector, and printed in the laboratory. The films were 17 minutes long.

Finally, the still slide versions were created by selecting appropriate visuals from the motion picture film and copying them as 2" x 2" color slides. A total of 66 slides were used. These slides reproduced all the pertinent visual material from the motion picture relating to the information being tested. Five sets of slides were assembled, one for each of the audio implementation treatments, and synchronized with the audio narrations, which had been re-recorded onto magnetic tape from the motion picture narrations. These five magnetic tapes were coded to activate slide changes when presented to the experimental groups. The slide versions were also 17 minutes long.

Thus, the audio implementation treatments were identical in content and length for the motion pictures and slides for each audio treatment, and the motion pictures and slide versions differed only in the depiction of motion and the selectivity of the slides used to convey the content of the motion pictures.

The Measuring Instruments

Performance Test

Description of the test. The performance test (see Appendix B) consisted of 67 verbal items, employing multiple-choice, true-false, completion fill-in, open-ended short answer, and ordering construction. Item types written for the performance test incorporated tasks defined by Bloom (1956) as Knowledge, Comprehension, and Application. The test included 32 Knowledge items, 19 Comprehension items, and 16 Application items.

Test development. All performance test items were developed through a tryout-revise-tryout cycle. Draft items designed to measure knowledge, comprehension, and application were prepared to sample each of the eleven major sequences in the films and slides. These items were then reviewed by the staff and three psychometricians.[1] Revised items were tried out with the first draft version of a film used in the earlier companion study. Scores were analyzed on an IBM 1401 computer, using phi and biserial programs provided by the Testing Bureau of the University of Southern California. Further revisions were then made and tried out with a second sample of the population. Minor revisions were made to refine the performance test before it was finally used in the experiment.

Reliability of the performance test, as used with the experimental group in the first tryout and as determined through use of Kuder-Richardson Formula #20, was .87. The reliability calculated for a control group that did not see the film was .65. The mean score for the first tryout experimental group was 30.17 and for the control group was 22.17, giving a difference score of 8.0. Reliability of the performance test as used in the second tryout was .91 with a mean score of 35.88.

Intelligence and Achievement Tests

The California Test of Mental Maturity scores were used to provide Total, Language, and Non-Language Quotient scores. The Iowa Tests of Basic Skills were used to provide scores for Vocabulary, Reading Comprehension, Language Skills, Arithmetic, and Work-Study Skills.

F Battery

The tests comprising the F Battery were assembled to measure certain capabilities of students, which, when evaluated with available IQ and achievement scores, might improve predictions of performance with audiovisual materials. This test was administered to all subjects two weeks after their exposure to the experimental stimuli. The expectation was that, if the F Battery would be useful in improving predictions in this context, it could be utilized when forecasting performance with similar stimulus materials. Explorations could then follow of the relationship of student abilities, not normally assessed by intelligence measures, and how performance and these abilities were related to certain combinations of instructional stimuli.

The F Battery was constructed by selecting a number of tests identified as being factorially unique by the research staff of the Psychological Laboratory of the University of Southern California (Guilford & Hoepfner, 1963). All the tests selected were based upon the "Structure of Intellect" model (Guilford, 1955). This model provided for a logical and systematic placement of every "known" intellectual ability. The tests chosen had been identified as being related to one of some 55 different intellectual abilities ascertained through the use of multiple-factor analysis by the Aptitude Project of the Psychological Laboratory. The test battery itself had been assembled for use in an earlier experiment (Allen, Filep and Cooney, 1967).

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[1] Dr. Paul Christensen, Human Factors Research Corporation, Santa Barbara, California; Dr. Philip Merrifield, Kent State University, Kent, Ohio; and Mr. Donald Estavan, Estavan Associates, Inglewood, California.

Tests were selected that measured the student's ability to identify, compare and contrast, and construct graphic figures. The specific tests that were selected measured the student's ability: to judge quickly and accurately units of figural information as being identical or dissimilar, to produce many simple figures that conformed to given specifications, to produce changes in figures that altered the meaning, significance or use of elements, to classify the same items of figural information in different ways, or to place events in correct sequence.

Semantic Differential

The *Semantic Differential* instrument consisted of eleven 7-point scales defined by adjective pairs representing three factors: Evaluative, Potency, and Action (see Appendix C). The rationale, construction, and analysis of this instrument has been described in Osgood, Suci, and Tannenbaum (1957).

Evaluative	Potency	Activity
good-bad	strong-weak	fast-slow
work-play	heavy-light	repetitious-varied
cruel-kind	feminine-masculine	loud-soft
pleasant-unpleasant		active-passive

The concept, "THE *STORY* YOU SAW ABOUT THE ECO-SYSTEM," was to be rated on each of the eleven scales. The scales were printed on mask sense forms so that scoring machines could be used to transfer the data to punched cards.

Conduct of the Experiment

Schedules and procedures were worked out in detail with the administrative staff of each school and then were reviewed with the teachers of the classes involved in the experiment. At the times of the experimental runs, the subjects met in their home rooms and were then taken to the appropriate experimental rooms as determined by their random assignment. The experimental rooms were regular classrooms set up for film projection. Students not scheduled for the first presentation were supervised on the playground or in a study hall, whichever contingency disturbed their normal schedules the least. All subjects in the experimental rooms were presented with the instructions, the stimulus films, and then tested immediately with the performance test and semantic differential measure. Following the administration of the experiment, these subjects were then moved to the playground or study hall, and the second experimental group was brought to the experimental rooms. Contact was avoided between these two experimental sections by keeping them separated during the passing periods.

Two weeks later the F Battery was administered to all the subjects, either in their own classrooms as intact class groups or in combined groups in cafetoriums, whichever was most convenient at the school.

Preparation of Data and Statistical Analysis

Recording the Data

All quantitative data were to be analyzed by computer; so appropriate formats were set up that would simplify detection and correction of errors in scoring of tests and in transfer of descriptive data from school records to the numbered cards used in the analysis.

During the experiment, subjects marked their answers directly on the test booklets.[2] These booklets were then grouped by treatment and scored twice independently on sensescore sheets. Guide keys were provided to each of two scorers to indicate acceptable and unacceptable answers. The two sensescore sheets for each test booklet were then compared and differences were resolved for all tests by a third individual.

Estimates of abilities and general achievement were provided from school records (Iowa Tests of Basic Skills and the California Test of Mental Maturity). Numbers assigned to students for purposes of randomization were used throughout the analysis to preserve the anonymity of the subjects and the integrity of their school records. IBM cards were punched manually from the lists of student data. The multi-part F Battery, used to measure selected aptitudes, was also scored once by each of two different scorers. Initial differences were resolved in conference with a third party to establish reasonably correct criteria. This approach eliminated most of the conflicting assessments. The remainder were brought to the third party for decision. Scores were transferred to sensescore sheets for mechanical transfer to IBM cards. All sensescore sheets, including those for the semantic differential were processed by the University Testing Bureau.

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[2] It was found during the tryouts that subjects had serious difficulty relating numbered items accurately to the sensescore sheets; so subjects marked answers directly to the test booklets.

Statistical Techniques and Computer Program

A series of descriptive analyses were undertaken to establish the quality of the data, to identify characteristics of the population and interrelationships among selected variables, and to provide a basis for selecting covariates to be used in the comparative analyses. All these analyses were undertaken on the Honeywell 800 computer, operated by the staff of the Computer Sciences Laboratory, University of Southern California. Factor analytic and covariance programs used were adapted versions of the BMD03M and BMD05V programs, respectively, described in Dixon (1965).

The principal components factor analysis used provided means and standard deviations, a correlation matrix, and a factor matrix useful in the selection of covariates for later analyses. An orthogonal rotation to the varimax criterion was performed on six factors.

Analyses of covariance were undertaken to establish the statistical differences among the experimental variables and to adjust the test scores for differences among the groups in vocabulary achievement and non-language IQ.

CHAPTER III

RESULTS

Test results were analyzed for total performance, for performance, for performance by high vs low mental ability groups, for performance of high vs low vocabulary ability groups, and for the total groups on each of the three performance subtests (knowledge, comprehension, and application items). In addition, qualitative responses on the semantic differential measure and reactions to the presentation were compared for all groups.

Descriptive Analyses

Homogeneity of Variance

Frequency distributions, associated polygons, and plots were computed to provide an estimate of homogeneity of variance among groups. Kurtosis of the distribution of raw scores was found by calculation to be significant at the .05 level.[3] However, after evaluation of this estimate, in view of the graphic descriptions mentioned above, in view of current estimates of its effects in the analyses to be undertaken, and in view of the analysis of covariance technique to balance for subject differences, sufficient confidence was held in the data to proceed (Kerlinger, 1964, pp. 258-259).

Selection of Covariates

Covariates for the analysis of covariance were selected by performing correlation and factor analyses of the test scores. Three criteria were used in the selection of the covariates. The first required that the covariates selected be meaningful in the context of the study to members of the educational community who might be using the reported results. Second, since only two covariates were to be used, it was important that one covariate have a large loading on one factor and the other covariate have a large loading on another factor. Third, these two covariates also had to have a low correlation with each other and a significant correlation with the total performance test.

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[3] Calculated on the Honeywell 800 computer with a program prepared by Richard Wolf and Leopold Klopfer, entitled "Test Scores and Statistical Analysis 2," of the Graduate School of Education, University of Chicago.

The covariates selected were Non-Language IQ and Vocabulary achievement. Both of the covariates selected were measurable by existing tests, thus meeting the first criterion. Examination of Table 1 shows that Non-Language IQ had a high loading (.557) on Factor 5 and that Vocabulary achievement had a high loading (.736) on Factor 1. Table 2 shows these two covariates to have a .45 correlation with each other, which was moderate within the range of possible covariates to be considered. Non-Language IQ correlated .42 with the total performance test, and Vocabulary correlated .77 with that test.

Analysis of Total Performance

The unadjusted and adjusted mean scores for the Total performance test and for the Knowledge, Comprehension, and Application subtests are presented in Table 3. Examination of the total adjusted performance test scores for the ten treatment groups shows a range of 39.34 to 42.75, a difference of only 3.41. The most effective treatment was the Directive Motion Picture and the least effective the Non-Linear Motion Picture.

A two-way analysis of covariance was performed on these data with Non-Language IQ and Vocabulary achievement used as the covariates. Table 4 presents the unadjusted and adjusted performance test means, the means for the two covariates, and the results of the analysis of covariance. No significant differences were found among the five audio implementation modes, between the two visual presentation modes, or for the interactions among these variables on the Total performance test. The F-ratio approached significance for the audio variable, however, and it is worth examining more closely the comparative effects of the audio implementation modes. The Non-Linear sound groups achieved the poorest performance with both the Motion Picture and Slide presentations, and the Question-Posing sound groups were also lower than the other audio implementation groups.

It is interesting to note that the Slide visual presentation groups performed at a slightly higher level than the Motion Picture groups in four of the audio implementation groups. Only with the Directive sound did the motion picture group outperform the slide group.

In summary, no significant differences were found for any of the variables studied or their interactions for the total population on the total performance test.

TABLE 1

FACTOR LOADINGS USED AS A BASIS FOR SELECTING COVARIATES APPLIED IN THE ANALYSIS OF COVARIANCE (N = 336)

Variable	Factors					
	1	2	3	4	5	6
Total Test	.762	.308	-.144	.101	.188	-.038
Sex	.755	.204	-.190	.141	.149	-.038
Vocabulary	.736	.237	.052	.020	.131	-.062
Reading	-.030	.075	.519	.005	.031	.012
Language Achievement	.826	.160	.158	.101	.331	.322
Arithmetic Skills	.533	.105	.389	.147	.690	-.087
Language IQ	.471	.276	-.084	.540	.545	.151
Non-Language IQ	.723	.202	.113	.315	.557	.121
Total IQ	.556	.327	.187	.342	.312	.109
Total F Battery	.119	.386	.012	.021	.013	-.013

TABLE 2

CORRELATION COEFFICIENTS USED AS A BASIS FOR SELECTING COVARIATES FOR THE ANALYSIS OF COVARIANCE (N = 336)

		1	2	3	4	5	6	7	8	9	10
Total	1		-.07	.77	.81	.58	.64	.63	.42	.57	.44
Sex	2			.08	.01	.20	.00	.11	.09	.12	.16
Vocabulary	3				.86	.74	.70	.72	.45	.63	.45
Reading	4					.69	.71	.70	.42	.61	.43
Language Achievement	5						.69	.66	.48	.62	.44
Arithmetic Skills	6							.68	.59	.70	.53
Language IQ	7								.59	.86	.52
Non-Language IQ	8									.92	.53
Total IQ	9										.59
Total F Battery	10										

TABLE 3

TOTAL PERFORMANCE TEST AND SUBTEST MEAN SCORES (UNADJUSTED AND ADJUSTED) AND STANDARD DEVIATIONS FOR TREATMENT GROUPS

		Total Score (67 items)			Knowledge (32 items)			Comprehension (19 items)			Application (16 items)		
	N	Unadj. $\bar{X}$	σ	Adj. $\bar{X}$	Unadj. $\bar{X}$	σ	Adj. $\bar{X}$	Unadj. $\bar{X}$	σ	Adj. $\bar{X}$	Unadj. $\bar{X}$	σ	Adj. $\bar{X}$
MOTION PICTURE													
Supplementary	30	43.43	11.27	41.18	21.77	5.70	20.71	13.57	3.51	12.92	8.10	3.13	7.57
Redundant	35	42.06	10.57	41.87	21.54	4.63	21.46	12.51	3.72	12.45	8.00	3.22	7.95
Directive	36	42.78	8.74	42.75	22.17	4.41	22.21	12.39	3.22	12.35	8.22	2.65	8.19
Question-Posing	35	37.60	11.28	39.43	18.69	5.80	19.56	11.60	3.56	12.13	7.31	3.08	7.74
Non-Linear	37	40.05	8.39	39.34	20.30	4.43	19.94	12.05	2.60	11.86	7.70	2.56	7.55
SLIDE													
Supplementary	35	43.80	10.88	42.06	22.69	5.24	21.86	13.03	3.71	12.54	8.09	2.94	7.69
Redundant	38	41.18	9.51	42.18	21.26	4.58	21.68	12.53	3.39	12.84	7.39	2.63	7.63
Directive	34	40.59	9.30	40.55	21.24	4.65	21.26	12.03	3.62	11.99	7.32	2.32	7.29
Question-Posing	36	39.75	11.44	40.31	20.61	5.52	20.88	11.47	4.05	11.64	7.67	3.14	7.80
Non-Linear	35	38.46	10.25	39.64	19.89	5.31	20.43	11.43	3.40	11.79	7.14	2.68	7.42
Total	351												

TABLE 4

COMPARISON OF AUDIO AND VISUAL PERFORMANCE TEST SCORES
BY ANALYSIS OF COVARIANCE
(Covariates: Non-Language IQ and Vocabulary)

		Criterion		Covariate $\overline{X}$		Adjusted Criterion $\overline{X}$
	N	$\overline{X}$	σ	Non-Lang. IQ	Vocab.	
MOTION PICTURE						
Supplementary	30	43.43	11.27	113.80	75.27	41.18
Redundant	35	42.06	10.57	108.51	72.06	41.87
Directive	36	42.78	8.74	105.22	72.06	42.75
Question-Posing	35	37.60	11.28	103.89	68.86	39.43
Non-Linear	37	40.05	8.39	111.78	72.70	39.34
SLIDE						
Supplementary	35	43.80	10.88	113.83	74.34	42.06
Redundant	38	41.18	9.51	108.66	69.95	42.18
Directive	34	40.59	9.30	105.56	72.06	40.55
Question-Posing	36	39.75	11.44	107.19	70.83	40.31
Non-Linear	35	38.46	10.25	107.06	69.74	39.64

	df	SS	MS	F	Prob.
Audio	4	381.44	95.36	2.24	—
Visual	1	0.07	0.07	0.002	—
Interaction	4	114.70	28.68	0.67	—
	339	14462.95	42.66		

Analysis by Learner Characteristics

Analyses were made of two learner characteristics in order to determine whether or not there was a learning differential in the way different types of learners responded to the different experimental treatments. The learner characteristics selected for analysis were the two covariates: Non-Language IQ and Vocabulary ability. The experimental population was split into High IQ (IQ ≥ 101) and Low IQ (IQ ≤ 100) and into High Vocabulary (above the mean) and Low Vocabulary (below the mean). The analysis of covariance of the IQ split used Vocabulary ability as the covariate, and the analysis of the Vocabulary split used IQ as the covariate.

Non-Language IQ

The unadjusted and adjusted mean performance test scores and the mean for the Vocabulary covariate are given in Table 5 for the High IQ and Low IQ groups separately. The Low IQ group showed considerably more variability among audio treatment modes than did the High IQ group. For the High IQ groups, the range among the ten treatment groups was 46.83 to 43.24, a difference of only 3.59; whereas the 39.40 to 32.25 range of the Low IQ groups showed a difference of 7.15. With the High IQ subjects, both the Supplementary Motion Picture and Supplementary Slide groups showed the highest performance, but the highest performance was registered by the Directive Motion Picture and Redundant Slide groups with the Low IQ subjects. The poorer performance by the subjects who received the Non-Linear sound treatments appeared to be contributed more by the subjects with the lower mental abilities.

The results of the analyses of covariance for the High and Low IQ groups are presented in Table 6. No significant differences were found among the five audio implementation modes, between the two visual presentation modes, or for the interactions among these variables for the subjects with higher mental ability. However, for the lower mental ability subjects, a difference significant at the .05 level was found among the five audio implementation modes. No significant differences were found between the visual presentation modes or among the audio/visual interactions.

The highest performance among the Low IQ subjects was by the Directive Motion Picture and the Redundant and Supplementary Slide groups. The lowest performance by these subjects was by the Question-Posing Motion Picture and the Non-Linear Slide groups.

In summary, significant differences were found only for the subjects of lower mental ability among the audio implementation treatments. Lowest performance was made by these subjects with audio treatments that posed questions to be answered or presented the audio in a non-linear way.

TABLE 5

TOTAL PERFORMANCE TEST MEAN SCORES (UNADJUSTED AND ADJUSTED) AND STANDARD DEVIATIONS FOR HIGH AND LOW VOCABULARY GROUPS

(Covariate: Non-Language IQ)

	High Vocabulary (above the mean)					Low Vocabulary (below the mean)				
		Criterion		Covariate $\overline{X}$	Adjusted Criterion		Criterion		Covariate $\overline{X}$	Adjusted Criterion
	N	$\overline{X}$	σ	N-L IQ	$\overline{X}$	N	$\overline{X}$	σ	N-L IQ	$\overline{X}$
MOTION PICTURE										
Supplementary	16	50.06	7.61	114.94	50.04	14	35.86	10.02	112.50	35.78
Redundant	17	49.18	6.82	111.12	49.60	18	35.33	9.02	106.06	35.97
Directive	19	47.32	6.77	112.00	47.64	17	37.71	7.97	97.65	39.30
Question-Posing	17	46.24	7.15	123.82	45.17	18	29.44	7.82	85.06	32.45
Non-Linear	23	32.61	7.15	115.48	43.52	14	34.21	7.02	105.71	34.89
SLIDE										
Supplementary	17	53.00	4.87	123.06	52.02	18	35.11	7.07	105.11	35.86
Redundant	22	46.45	7.02	114.45	46.48	16	33.94	7.58	100.69	35.19
Directive	18	46.06	5.99	105.28	47.17	16	34.44	8.56	105.88	35.10
Question-Posing	19	47.95	5.88	113.32	48.12	17	30.59	8.86	100.35	31.88
Non-Linear	17	44.00	9.60	114.71	44.00	18	33.22	7.99	99.83	34.56
Total	185					166				

TABLE 6

RESULTS OF ANALYSIS OF COVARIANCE FOR HIGH AND LOW NON-LANGUAGE IQ GROUPS
(Covariate: Vocabulary)

	df	SS	MS	F	Prob.
HIGH IQ (≥ 101)					
Audio	4	164.94	41.24	1.04	—
Visual	1	4.82	4.82	0.12	—
Interaction	4	34.39	8.60	0.22	—
Within	191	7558.60	39.57		
LOW IQ (≤ 100)					
Audio	4	512.15	128.04	2.66	< 0.05
Visual	1	2.88	2.88	0.06	—
Interaction	4	70.92	17.73	0.89	—
Within	138	6646.95	48.17		

Vocabulary Achievement

The unadjusted and adjusted mean performance test scores and the mean for the Non-Language IQ covariate are given in Table 7 for the High Vocabulary and Low Vocabulary groups separately. Both the vocabulary groups showed considerable variability among the treatment modes. For the High Vocabulary groups, the range among the ten treatment groups was 52.04 to 43.52, a difference of 8.52. For the Low Vocabulary groups, the range was 39.30 to 31.88, a difference of 7.42. The High Vocabulary subjects showed a consistent pattern of performance, largest gains being made by the Supplementary sound groups and lowest gains by the Non-Linear sound groups. Directive sound was a greater contributor to learning and Question-Posing a detriment among the Low Vocabulary groups.

The results of the analyses of covariance for the High and Low Vocabulary groups are presented in Table 8. A highly significant difference of .01 was found for the High Vocabulary groups among the five audio implementation modes, but no significant differences for the Low Vocabulary groups. Neither the visual implementation modes nor the audio/visual interactions showed significant differences for either group.

The significant differences for the High Vocabulary groups revealed a clear-cut superiority of the Supplementary sound mode and a clear-cut inferiority of the Non-Linear sound mode.

In summary, significant differences were found only for the subjects with the higher vocabulary achievement among the audio implementation treatments. Highest performance was made by these subjects with audio treatments that presented the audio in an augmented "conventional" way and poorest performance by subjects with audio treatments that posed questions to be answered or presented the audio in a non-linear way.

Analysis of Performance Subtests

The performance test consisted of items that tested Knowledge, Comprehension, or Application as defined by Bloom (1956). Although these items were distributed throughout the test, when separately analyzed they comprised the subtests, scores of which were presented in Table 3 for each treatment group.

The pattern of performance on the three subtests was similar to that on the total performance test with the exception of the Application subtest, which showed generally comparable scores among the ten treatments. The results of the analysis are shown in Table 9.

The only significant differences shown were for the Knowledge subtest among the audio implementation modes. This difference was at

TABLE 7

TOTAL PERFORMANCE TEST MEAN SCORES (UNADJUSTED AND ADJUSTED) AND STANDARD DEVIATIONS FOR HIGH AND LOW NON-LANGUAGE IQ GROUPS
(Covariate: Vocabulary)

	High IQ ($\geq$ 101)					Low IQ ($\leq$ 100)				
		Criterion		Covariate $\overline{X}$	Adjusted Criterion		Criterion		Covariate $\overline{X}$	Adjusted Criterion
	N	$\overline{X}$	σ	Vocab.	$\overline{X}$	N	$\overline{X}$	σ	Vocab.	$\overline{X}$
MOTION PICTURE										
Supplementary	18	47.17	10.36	79.50	46.00	12	37.83	10.57	68.92	35.21
Redundant	20	44.80	10.30	77.15	45.00	15	38.40	10.13	65.27	37.68
Directive	21	44.86	8.24	77.24	45.01	15	39.87	8.85	64.80	39.40
Question-Posing	20	44.75	8.26	78.60	44.11	15	28.07	6.76	55.87	32.25
Non-Linear	23	43.43	7.94	77.17	43.24	14	34.50	5.91	65.36	33.74
SLIDE										
Supplementary	19	48.63	9.56	80.58	46.83	16	38.06	9.70	66.94	36.47
Redundant	22	44.86	7.63	75.55	46.00	16	36.12	9.73	62.25	36.97
Directive	17	43.12	8.35	76.24	43.86	17	38.06	9.74	67.88	35.98
Question-Posing	21	44.43	9.28	78.24	44.00	15	33.20	11.20	60.47	34.98
Non-Linear	21	43.29	8.09	75.24	44.61	14	31.21	8.95	61.50	32.45
Total	202					149				

TABLE 8

RESULTS OF ANALYSIS OF COVARIANCE FOR HIGH AND LOW VOCABULARY GROUPS

(Covariate: Non-Language IQ)

	df	SS	MS	F	Prob.
HIGH VOCABULARY (above mean)					
Audio	4	983.52	225.88	5.63	< 0.01
Visual	1	6.10	6.10	0.14	—
Interaction	4	203.33	50.83	1.16	—
Within	185	7596.56	40.9		
LOW VOCABULARY (below mean)					
Audio	4	453.55	113.41	1.78	—
Visual	1	55.48	55.48	0.87	—
Interaction	4	96.48	24.12	0.38	—
Within	155	9875.66	63.71		

TABLE 9

RESULTS OF ANALYSIS OF COVARIANCE WITH SUBTESTS: KNOWLEDGE, COMPREHENSION, APPLICATION
(Covariates: Non-Language IQ and Vocabulary)

	df	SS	MS	F	Prob.
KNOWLEDGE SUBTEST					
Audio	4	157.79	39.45	3.18	< 0.025
Visual	1	17.54	17.54	1.41	—
Interaction	4	56.08	14.02	1.13	—
Within	339	4210.60	12.42		
COMPREHENSION SUBTEST					
Audio	4	48.41	12.10	1.82	—
Visual	1	3.00	3.00	0.45	—
Interaction	4	8.91	2.23	0.34	—
Within	339	2252.93	6.64		
APPLICATION SUBTEST					
Audio	4	4.80	1.20	0.26	—
Visual	1	4.75	4.75	1.04	—
Interaction	4	11.59	2.90	0.63	—
Within	339	1553.26	4.58		

the .025 level and favored the Directive, Redundant and Supplementary sound versions over the Question-Posing and Non-Linear sound in both visual presentation modes. These results were consistent with the analyses reported above and suggest that the acquisition of knowledge was more directly affected by the mode of audio narration than either comprehension of the material or the ability to apply the learning.

In summary, significant differences were found only for the audio implementation treatments on the subtest items that related to the acquisition of knowledge.

Qualitative Analyses

Measures were made of the state of mind of the subjects as they experienced the experimental situation. The semantic differential instrument (see Appendix C), consisting of eleven 7-point scales, was administered immediately following the administration of the experimental stimulus treatments. The concept, "The Story You Saw About the Eco-System," was rated on each of the scales. Since the purpose of the analysis was comparison among treatment groups, t-tests were computed to establish the order of differences between means for each group on each of the eleven scales. Differences found to be significant at the .05 level or less are presented in Table 10. The means for the groups and the items referenced are presented in Table 11. The tables may be used together. For example, it was found that the Supplementary Motion Picture and the Question-Posing Motion Picture groups differed significantly at the .05 level on Item No. 2 of the scale (WORK/PLAY). Their means were 2.79 and 3.37; that is, the Supplementary Motion Picture group found the stimulus material significantly more "work" than did the Question-Posing Motion Picture group. Inasmuch as the scalar center is 4, both groups found the stimulus more "work" than "play."

In general, all the experimental treatments were perceived to be GOOD, WORK, KIND, very SLOW, and MASCULINE. Of these five ratings, held unanimously by all experimental groups, three were on the Evaluative dimension of the semantic differential. The largest numbers of significant differences between treatment groups was for the FAST/SLOW (16 significant differences), PLEASANT/UNPLEASANT and ACTIVE/PASSIVE (13 significant differences), and GOOD/BAD (10 significant differences) dimensions of the scale.

Comparing the responses of the audio implementation groups for both the visual presentation modes, the Question-Posing sound was evaluated more positively than the other sound treatments and the Non-Linear sound as more negative. The Supplementary sound group rated the

TABLE 10

SIGNIFICANCE OF DIFFERENCES BETWEEN GROUP MEANS ON ITEMS IN THE SEMANTIC DIFFERENTIAL

	MOTION PICTURE					SLIDE				
	Supp.	Redund.	Direct.	Quest.-Pos.	Non-Lin.	Suppl.	Redund.	Direct.	Quest.-Pos.	Non-Lin.
MOTION PICTURE										
Supplementary				-2/.05* 4/.05	-1/.01 -4/.05 -6/.01			-1/.02	-8/.05	-10/.02
Redundant				-2/.05 9/.05	-1/.05 -4/.01 -6/.01	7/.05		-1/.05 -4/.02 9/.02		10/.05
Directive				5/.05 9/.05	3/.02 -4/.01 -6/.01	-4/.05 7/.05 -10/.05	-4/.05	3/.05 -4/.07 -6/.05 9/.02 -10/.05		-4/.01 -6/.05 -10/.01
Question-Posing					-1/.01 -4/.01 -5/.05 -6/.01	-4/.01 7/.01 -10/.05	2/.05 -4/.01 -9/.05	-1/.01 2/.05 -4/.01 -6/.05 -10/.05	-4/.01	-4/.01 -6/.05 -10/.01
Non-Linear						6/.05 7/.05	1/.02 6/.01 10/.05	6/.05	1/.02 -3/.01 4/.05 5/.05 6/.05	6/.05
SLIDE										
Supplementary							-7/.02 10/.02		-3/.05 -7/.05	-7/.05
Redundant								-1/.05 9/.02 -10/.02	-3/.05	-10/.01
Directive									1/.05 -3/.01	
Question-Posing										-10/.02
Non-Linear										

*First figure presented is the item number; second is level of significance determined by t-test. Read group to left first, then group on top. If sign for the item number is negative, read top group first.

TABLE 11

GROUP MEANS FOR ITEMS IN THE SEMANTIC DIFFERENTIAL
(Center of Scale = 4)

	Items										
	1	2	3	4	5	6	7	8	9	10	11
MOTION PICTURE											
Supplementary	3.00	2.79	4.70	5.41	3.73	3.52	3.58	4.09	3.67	3.79	3.73
Redundant	3.26	2.74	4.66	5.11	3.84	3.65	3.71	4.47	3.97	4.05	3.84
Directive	3.37	3.11	4.87	4.78	3.87	3.34	3.87	4.50	4.05	3.66	3.53
Question-Posing	2.97	3.37	4.66	4.49	3.26	3.37	4.09	4.34	3.40	3.74	3.69
Non-Linear	3.95	3.10	4.12	6.02	4.05	5.00	3.69	4.44	3.41	4.38	3.95
SLIDE											
Supplementary	3.63	3.11	4.43	5.57	3.78	4.08	2.84	4.49	3.61	4.53	3.71
Redundant	3.24	2.87	4.46	5.60	3.68	3.70	4.14	4.42	4.00	3.54	3.61
Directive	3.94	2.80	4.35	6.06	3.66	4.23	3.49	4.44	3.26	4.60	3.69
Question-Posing	3.23	2.95	5.08	5.44	3.28	3.72	3.71	4.72	3.64	3.92	3.74
Non-Linear	3.45	3.00	4.53	5.71	3.58	4.13	3.82	4.42	3.50	4.90	3.58

motion picture film as GOOD,[4] but the slide presentation as REPETITIVE, SLOW and PASSIVE. The Redundant sound group rated the motion picture film as GOOD, FAST and SOFT, but the slide presentation as SLOW and PASSIVE. The Directive sound group rated the motion picture film as FAST, PLEASANT and ACTIVE, but the slide presentation as BAD, SLOW, LOUD and PASSIVE. The Question-Posing sound group rated the motion picture film as FAST, PLEASANT and ACTIVE and the slide presentation as GOOD and KIND. The Non-Linear sound group rated the motion picture film as BAD and UNPLEASANT and the slide presentation as SLOW and PASSIVE.

Comparing the responses of the visual presentation groups for all the audio implementation modes, the motion picture modes were rated much more positively than the still slide modes. The still slide groups rated their visual presentation as SLOW, REPETITIVE and PASSIVE (with the exception of Question-Posing sound); whereas the motion picture groups rated their visual presentations as PLEASANT, FAST and ACTIVE (with the exception of Non-Linear sound). The slide group found the Question-Posing sound as GOOD and KIND, and the motion picture group found the Non-Linear sound as BAD and UNPLEASANT. The motion picture film responses tended to be divided between the Evaluative and Activity dimensions; whereas the still slide responses were almost all related to the Activity dimension. The only significant Evaluative responses for the still slide groups was for the Directive sound (rated BAD) and the Question-Posing sound (rated GOOD and KIND). It may be that the slow pacing of the slides evoked more negative responses when attention was directed to them, but more positive responses when the narration was more informal and engaged their involvement when questions were asked.

In summary, there was extremely strong evidence that the motion picture groups perceived the sound films more positively than the still slide groups perceived the sound slides. The motion picture films were found to be comparatively more active and the slides less active.

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[4] These ratings are comparative: that is, they represent ratings in relation to other experimental treatments and not necessarily to the scalar center. Their positions on the scale may be obtained from Table 11.

CHAPTER IV

CONCLUSIONS, DISCUSSION, AND IMPLICATIONS

This chapter will present the specific conclusions that may be derived from the data, discuss the results of the study, and suggest implications of the study for the design of instructional media.

Conclusions

The following conclusions may be made from an analysis of the results of the study:

1. No significant differences in learning were found among the audio implementation or visual presentation variables or their interactions for the total population on the total performance test.

2. When split into high and low mental ability groups, significant differences in learning were found only for the subjects of lower mental ability among the audio implementation treatments. Poorest performance was with audio treatments that posed questions to be answered covertly or presented the audio in a non-linear way.

3. When split into high and low vocabulary ability groups, significant differences in learning were found only for the subjects with the higher vocabulary achievement among the audio implementation treatments. Highest performance was with audio treatments that presented the audio in an augmented "conventional" way and poorest performance was with audio treatments that posed questions to be answered or presented the audio in a non-linear way.

4. When the three subtests were analyzed separately for the total groups, significant differences in learning were found only for the audio implementation treatments on the subtest items that related to the acquisition of knowledge in favor of the Directive, Redundant and Supplementary audio treatments over the Question-Posing and Non-Linear audio treatments in both visual presentation modes.

5. The qualitative analyses indicated that the motion picture groups perceived the sound films more positively than the still slide groups perceived the sound slides. The motion picture films were rated as being more active and the still slides as less active.

6. Overall, the study revealed little difference in learning from motion picture films or slides when implemented with different styles of audio narration. Students of lower mental ability appeared to be deterred in their learning by narrations that asked questions or presented the narration in a non-linear way, and these audio implementation styles seemed to most directly influence the acquisition of knowledge. There appeared, however, to be no direct relationship between performance on the test and affective rating of the instructional communication.

Discussion

Although the overall effects of the study tended to reveal no particular advantages for any of the audio implementation or visual presentation modes so far as the enhancement of learning was concerned, there are several aspects of the study and the results that deserve further discussion.

Explanation of the Overall Results

It is important to discover the possible explanation for the lack of significant effects among the variables being studied. Either one or a combination of the following conditions could account for the results.

First, the design variables (audio implementation and visual presentation), as employed in this experiment, may, in fact, have exerted no measurable influence on the learning of the content. Or nature of the content may have been such that it did not interact with the variables studied. In the light of the previous research, however, and the measurable differences that were obtained from the subsidiary analyses conducted, this explanation is difficult to accept without question.

Second, the subjects may have had such a high level of previous knowledge about the content of the stimulus materials that the possible effects of the experimental variables were masked out, and the relatively short duration of the stimulus (17 minutes) may not have had an opportunity to present enough content to override this prior knowledge. Although this study did not employ a control group (which would take the performance test but not view the stimulus material), the previous companion study reported by Allen, Weintraub and Cooney (1968) did so. It will be remembered that the present study utilized (as the Supplementary Motion Picture treatment) one of the sound motion picture films from that study. In the previous study, the difference in learning between that film and the control group was 43.57 to 26.64, a difference of 16.93 points in favor of the film group, significant at less than the .001 level. Because the subjects were taken from the same experimental populations and the scores on the performance test were almost identical for the same film in the two experiments (43.57 and 43.80), there is every reason to believe that the level of previous knowledge in the present study was also at a relatively low level and that the experimental treatments added significantly to the learning. Thus, this explanation for the lack of significant differences among the treatment group studied should probably be ruled out.

Third, the performance test itself may have been insensitive to the variations in learning produced by the experimental treatments. There is some evidence that the experimental subjects found the test to be easier than the test tryout population. Item analyses after the first tryout showed most items to be too difficult, and corrections were made to make them easier. The second tryout confirmed the results of these changes, the group mean being about 50% correct answers. However, the mean for the entire experimental population was about 61% correct answers, this group finding the test much easier. Since the subjects from both the tryout and experimental schools were comparable on measured dimensions, the only change that might account for so large a shift was procedural. During the tryout, rather complex IBM sensescore sheets were used, necessitating the transfer of answers from the test booklet to the answer sheets. Because the tryout subjects found these sheets difficult and hard to use, a procedure of direct answering in the test booklet itself was utilized with the experimental population. Thus, the procedure used with the tryout groups may have made the test appear to be more difficult. So the performance test may have been a slightly blunted instrument with a ceiling lower than desirable. However, it is felt that this slight insensitivity in the test was not sufficient to account for the failure of the experimental variables to produce increased learning.

Fourth, the design elements that were built into the experimental materials, other than the experimental variables, may have resulted in a level of learning beyond which differences were difficult to obtain or to detect. The high levels of learning (65.4% of the maximum possible) achieved by the group with the best performance and only a slightly lower score (60% of the maximum possible) achieved by the group with the poorest performance appear to confirm this. Examining the scripts of the experimental treatments (Appendix A), it will be seen that considerable repetition was built in. An effort was made by the researchers to design as effective a teaching instrument as possible (excluding the experimental variables). This factor may have resulted in a condition where the audio implementation and visual presentation variables performed an additive function only. Because the basic motion picture and slide versions had raised the level of achievement about as high as could be expected, these additive features had little opportunity to increase the learning significantly. Repetition, as has been pointed out in research reviews by Allen (1960) and Lumsdaine (1963), is an important factor in increasing learning. The experimenters, in attempting to design an effective basic communication, may have underestimated just how powerful this variable could be.

There is no assurance, of course, that this was the cause of the nonsignificant differences obtained in the study, but it probably had some effect on the results.

The Audio Implementation Variable

The consistent tendency of the Supplementary, Redundant and Directive sound treatments to outperform the Non-Linear sound treatment suggests that those three treatments may have characteristics in common not possessed by the latter treatment. It is immediately apparent that the audio narration of the three treatments was much longer (1530 words for the Supplementary, 1320 words for the Redundant, and 1490 words for the Directive) than the audio narration for the Non-Linear treatment (950 words). However, the Question-Posing treatment, on which the test performance was also low, was 1450 words long. So the actual density of the narration, as determined by word count, may not be a crucial factor in learning if within the limits of comprehensibility. Zuckerman (1949) considered any number under 100 words per minutes as in the range of "low" verbalization, and even the longest of these treatments was delivered at a mean rate of only 90 words per minute. Therefore, a more important factor might be the number of repetitions of the points of information being communicated. A tabulation of a sample of fourteen major concepts presented in the experimental treatments and tested showed that the Supplementary narration repeated the key words of these concepts a total of 95 times (42 times for the food, warmth, light, and safety needs). On the other hand, the Non-Linear narration repeated the key words of the same concepts a total of 75 times (37 times for the food, warmth, light, and safety needs). This comparison indicates that the Supplementary version had a higher concept repetition rate, and it is certainly feasible that this factor might have contributed to poorer test achievement of the Non-Linear treatment groups. However, we have no criterion for determining the precise number of repetitions necessary to acquire a concept which is to be immediately tested. For example, "eco-system" was repeated nine times in the Supplementary sound version and seven times in the Non-Linear sound version. We have no way of knowing, from this study, whether the additional audio exposure (two repetitions) of the Supplementary group to this term led to more complete "learning" of this concept. But the fact remains that the audio treatments did differ on this dimension, and the level of student performance may have been influenced by this fact.

The problem of designing and writing "pure" versions of particular audio narration styles should be pointed out. The requirements of this study dictated that each audio implementation treatment conform as closely as possible to a uniform style for each mode. This meant that it was often necessary to employ narration styles that were not necessarily the optimum styles to use. Also, the employment of the same style (particularly of the Directive, Question-Posing and Non-Linear modes) for the entire 17-minute duration of the stimulus presentation may have weakened the overall impact of those modes because of the repetitive sameness of the presentation. The Supplementary sound and Directive sound versions most successfully conformed to their design requirements. The Redundant sound was, in some ways, "supplementary" in its characteristics; it was not redundant in the sense that van Mondfrans and Travers (1965) and Travers (1967) defined redundant—that is, both audio and visual presented in exact simultaneous synchronization. Rather, it described what was appearing in the visuals, but did have to contain some explanatory and transitional content. The Question-Posing sound version used the questioning technique more as rhetorical questions than as devices to elicit covert responding. The requirements of non-linearity were difficult to meet with the Non-Linear sound version, as audio narration itself is linear. The feeling of non-linearity could be obtained largely through changing of pace and the use of staccato delivery. In some ways, the Non-Linear treatment had a "redundant" quality: that is, single words and phrases coincided with their visual counterparts without further verbal embellishment.

A further comment needs to be made about the Non-Linear sound mode and the earlier prediction that this style of narration might obtain audience involvement and enhance the learner's "feelings about" the content. The results of the semantic differential comparisons failed to bear out this prediction. In fact, the learner's affective responses to this style of treatment were negative ones. There is no ready explanation why this should have been the case, but possibly the extreme "slowness" of this audio mode (only about 55 words per minute) had something to do with this response. When this extremely slow pace was coupled with the static quality of slide presentation, a negative affective response may have been generated.

The Visual Presentation Variable

The finding that the still slide presentation groups achieved at a level equal to the motion picture film groups is not surprising in the light of previous research. Many audiovisual specialists hold the belief that motion pictures are superior teaching instruments to slides or filmstrips because of their enhanced reality and the quality of motion. When studied under experimental conditions, such has not proven to be the case, even though learners prefer the motion picture mode. This study supported the earlier findings: a more positive affective rating for the motion picture, but no differences in cognitive learning.

Learner Characteristics

The finding that the subjects with low mental ability performed at a lower level with the Question-Posing and Non-Linear sound treatments cannot be readily explained. It is possible that the frequent insertion of questions tended to distract these subjects as they thought of the answers, thus interfering with the information that followed and that the Non-Linear treatment did not give them the quantity of information carried in the other treatments.

The relatively high performance by the Supplementary sound groups by subjects with high vocabulary achievement is also difficult to explain. Perhaps the subjects with high vocabulary ability reacted favorably to a higher word-per-minute density and unfavorably to the somewhat barren narration of the Non-Linear treatment. Whatever the reason, the largest inter-group differences were found for the High Vocabulary subjects: 6.52 in the motion picture mode and 8.02 in the slide mode between the Supplementary and Non-Linear sound groups.

Implications

The implications of this study for the design of instructional media seem to be more negative than positive. That is, the possible differential effects of audio implementation variables and their interactions with visual presentation modes did not materialize. This does not mean, of course, that such variables are not important in the design of instructional media; but that, under the conditions prevailing in this experiment, they did not produce the expected results.

It may be, as discussed above, that the repetition built into the stimulus materials was sufficiently pervasive to override the effects of the experimental variables. If so, this fact itself has implications for the design of instructional materials apart from the variables under study.

It seems fairly obvious, however, that the utilization of a uniform audio implementation style for an entire instructional film or sound filmstrip would not be desirable. But the precise mix of audio elements and their relationships to content, objectives, learner characteristics, and visual modes, must be determined by future experimentation.

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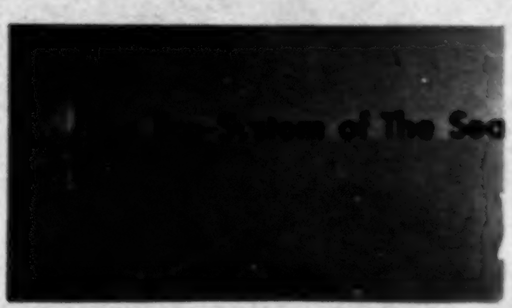
APPENDIX A

SCRIPTS OF EXPERIMENTAL TREATMENTS

EXPLANATION: The script shown immediately below was for the Supplementary audio implementation treatment. The illustrations show the slides used in the Slide treatments and the key points in the Motion Picture treatments. Following this script, the narrations for the four other treatments are shown. The scene numbers indicate comparable audio and visual content in all five treatments.

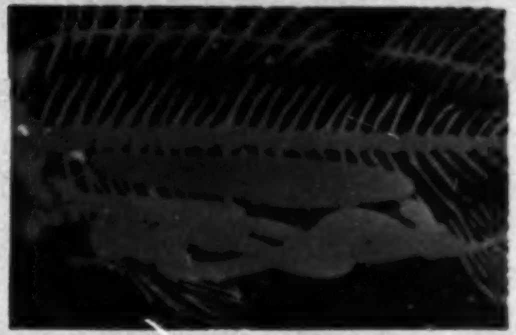
SUPPLEMENTARY AUDIO

VISUAL



1. A fish has an interesting way of moving up and down in the water.

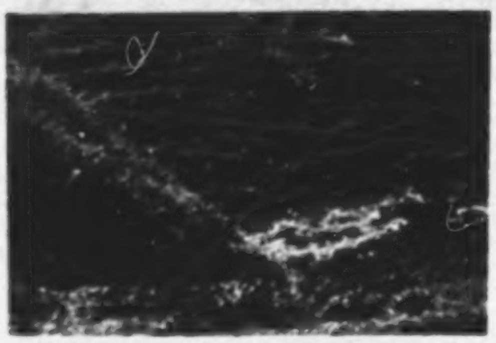
2. It does this by means of its swim bladder ...



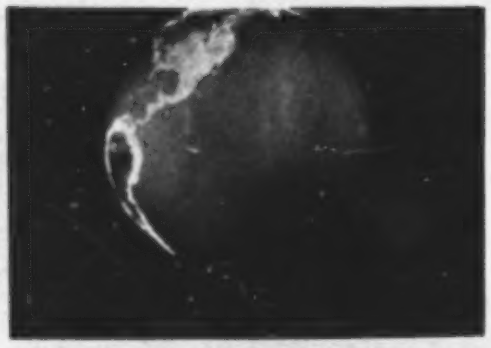
3. ... which, if filled with air, enables it to rise in the water ...

4. ... if partly filled or empty, to sink in the water.

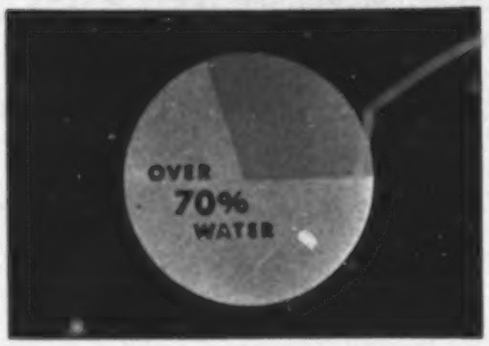
5. This reminds us that ... we live on a planet of lands and of oceans.



6. Our planet is called the earth ...

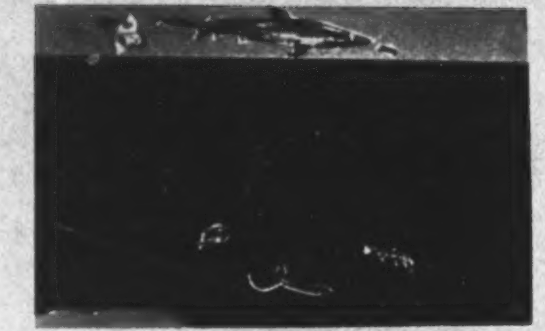


7. ... yet over 70% of its surface is covered by water ... water found in the great oceans of the earth.



8. In these oceans are many forms of animal life ... and plant life ... animal and plant life that we call marine life because they live in the ocean or sea.

9. There is marine life at all depths of the sea, but each form of marine life has a particular place it usually lives. Some forms live near the brightly lit top ... some deeper down in the dimly lit area ... and others in the very deep dark ocean ... even near the earth on the bottom of the sea. So there is marine life at every depth in the sea.

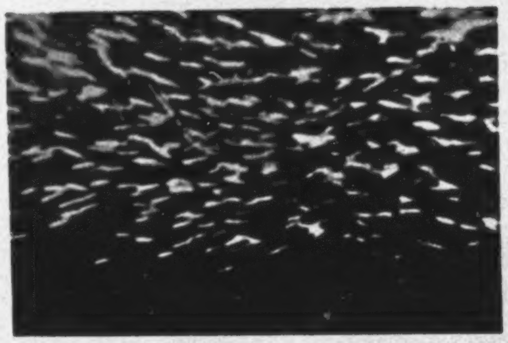


10. Changes in the nature of the sea ... its winds, tides, saltiness and so on ... cause different forms of marine life to live where they live.

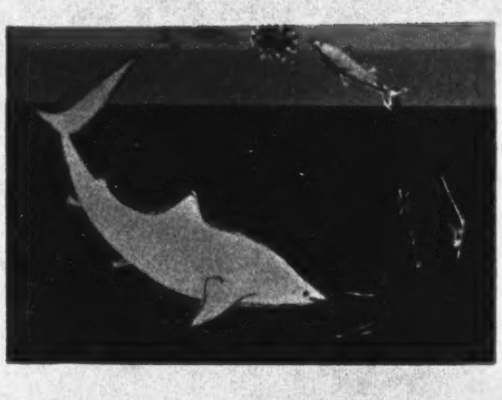
11. Also important to where each form of marine life lives are its own special needs. One of these needs is food. Each form of marine life needs its own kind of food.

12. And one form of marine life becomes food for another form of marine life.

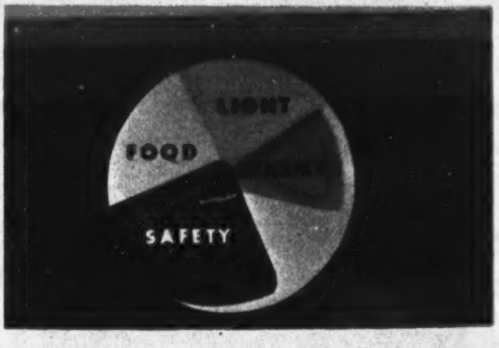
13. This need for food goes on ... and on ... and on ... throughout the sea.



14. The great circle of marine life ... one form feeding on another ... is often called a food-chain. What we see at work here is a system by which every form of marine life finds the food which it needs.



15. Food, then, is a need that makes each form of marine life live where it lives. Marine life has many other important needs: like keeping from getting caught and becoming food itself ... or like getting light enough to see both its food and its enemies ... or like keeping warm enough while moving toward lights, food, or safety. Each form of marine life has many needs--all related to one another, and all parts of one system.



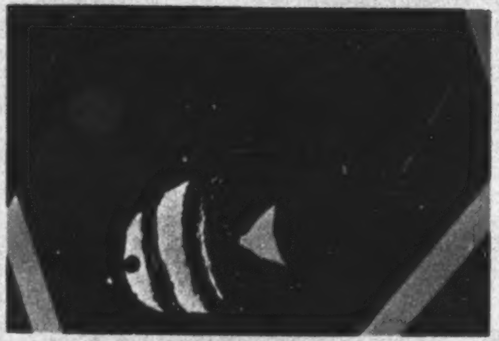
16. Scientists give this system a rather big name: they call it an ecological system.

17. But scientists sometimes shorten such big names. Many of them call this system the eco-system of the sea.

18. Each form of marine life has its own place to live, its own way of fitting into the eco-system of the sea, its own needs. Because of such needs, each form of marine life seems to have a fence around its usual place to live.

19. A quite imaginary fence ... one which marks the limits, let us say, to which a fish usually will go. By limits we mean the edges of that area within which a fish might find enough food, yet not too much danger ... enough light or darkness, yet not too much warmth or cold ... Not too much, nor yet too little, of whatever it needs.

20. We give a name to what keeps marine life inside such imaginary fences: we call it the Law of the Limits.



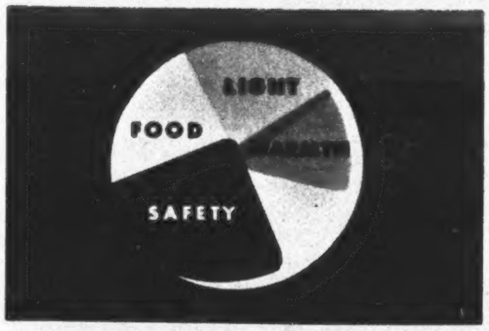
21. If we knew all there is to learn about the Law of the Limits, we would know just where to find each form of marine life in the eco-system of the sea.

22. We shall learn much more about the eco-system of the sea and its Law of the Limits if we think about how one need of marine life can relate to all others.

23. Think about light! Most of the light in the sea comes from the sun. But sunlight reaches nowhere near so far through the water as it does through the air.

24. Sunlight comes down in many colorful rays. But the warmer rays of the sun reach down only 250 feet into a sea which is up to seven miles deep. Deeper than these bright rays can reach, the cooler rays light and warm the sea for another few hundred feet. The rest of the sea is quite cold and dark as we go down ... as if in a submarine ... down to the floor of the sea.

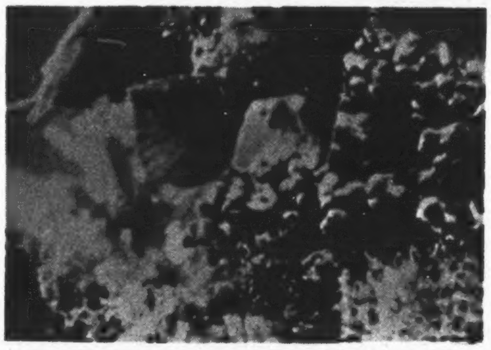
25. Light is related, not only to warmth, but also to safety.



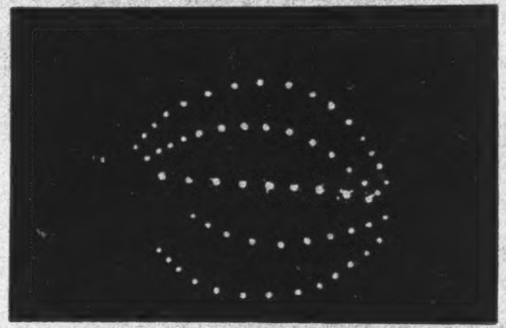
26. Many forms of marine animals are colored in such ways that they blend into their surroundings and are hard for their enemies to see or find.

27. Some blend into the light above ... some blend into the darkness below ...

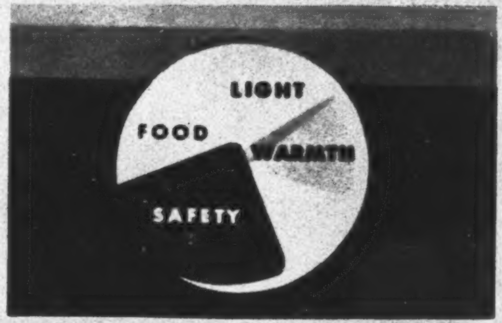
28. ... and some resemble the places in which they hide.



29. Those in the deep, dark depths of the sea may be able to flash lights of their own, helping them to see or to scare their enemies.



30. In the eco-system of the sea, then, light is related to warmth and to safety. Also to food.



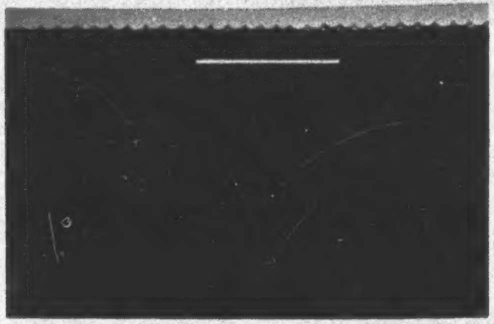
31. Earlier we learned that plants start the food-chain in the eco-system of the sea. Let us learn now how plants themselves are fed. The sea, like the land, has within it the chemicals, or fertilizer, which plants use as food.

32. The plants of the sea, often without roots, and floating on the waves, soak up these chemicals and make them into food ...

33. ... through a process called photosynthesis ... a process that works only when light is present.

34. Where light and the right chemicals are plentiful, photosynthesis can happen in millions of tiny plants ... plants too small for one to see without help ...

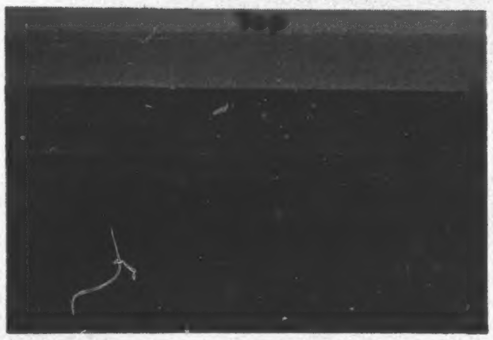
35. ... plants called plankton.



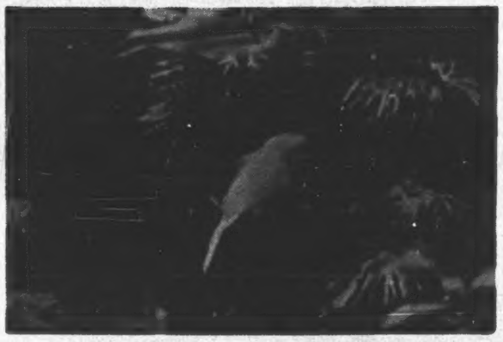
36. The same name--plankton--is given to millions of tiny shrimp-like animals which live with and feed on the tiny plankton plants.

37. The food chain in the eco-system begins with these tiny plankton: plankton plants and plankton animals.

38. In this food-chain of the eco-system, we must look for plant life mainly near the top of the sea.

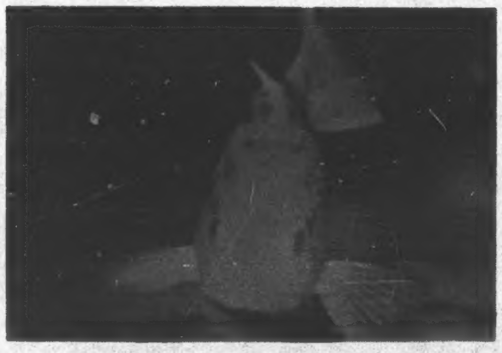


39. Marine animals in this brightly lit top of the sea eat plants and each other.



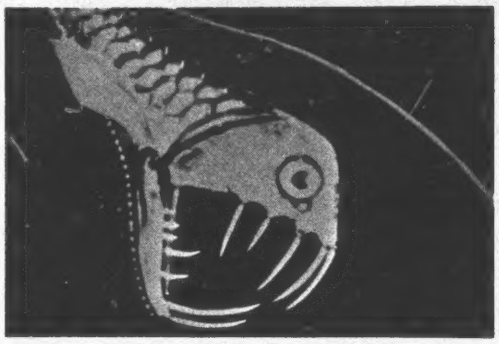
40. A little deeper in the sea, in the dimly lit middle part, different forms of marine animals also eat each other.

41. In addition, they eat some of the dead plants and animals which drift down from higher up in the sea.



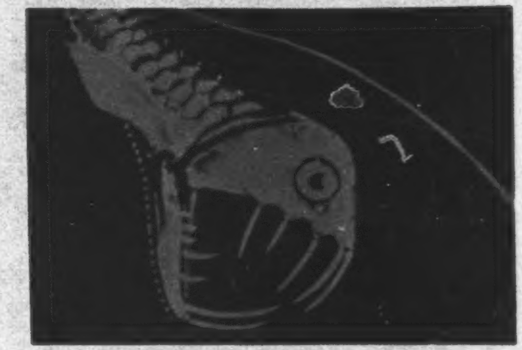
42. But most of the dead plants and animals ... the garbage and debris of the sea ... drift down through the deep darkness below ...

43. ... there to be eaten by very strange forms of marine animals, some of which may also eat each other.



44. Miles deep through the sea is, what happens at the brightly lit top is related to ...

45. ... what happens at the darkest point below.



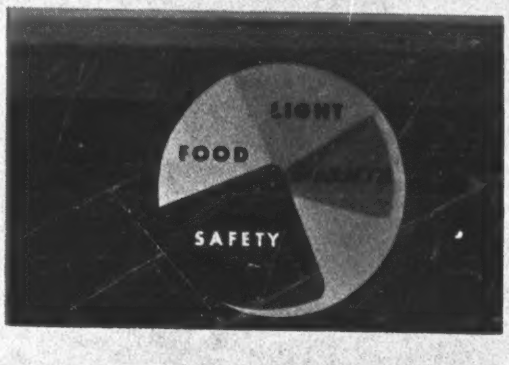
46. From the ocean floor scientists bring up ooze and clay which is as much as two miles thick at the bottom of the sea. In such mud they find signs of dead animals and plants ... and of chemicals made at the bottom of the sea by very tiny organisms.

47. These tiny organisms are called bacteria.

48. The chemicals made by the bacteria dissolve in the dark ocean waters ...

49. ... then rise in the moving waters to the top of the sea where plants use them for food during photosynthesis.

50. We have seen that light is related to warmth, safety and food in the eco-system of the sea.



51. But the story of light and food is not complete until we learn how the dissolved chemicals come up from the ocean floor to reach the light.

52. The sea is always in motion. Warm water at the top keeps moving away. Cold water, full of dissolved chemicals, keeps coming up from below to be warmed. But this change would be very slow were it not for the winds over the sea. These winds push the warm waters away from the hot equator, making such waters flow away like rivers through the waves and tides of the sea.

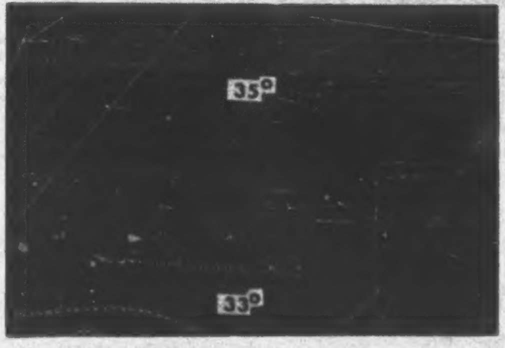
53. And such currents ... as these moving waters are called ... flow away from the hot equator toward the cold poles, north and south. There the currents grow cold, sink to the bottom of the sea, then flow back toward the equator along the ocean floor ...

54. ... there to rise and replace the warm water which has moved away from the equator. It is, then, the great movements of currents, with their upward motion of water from below, which bring up the chemicals from the ocean floor for use in photosynthesis.

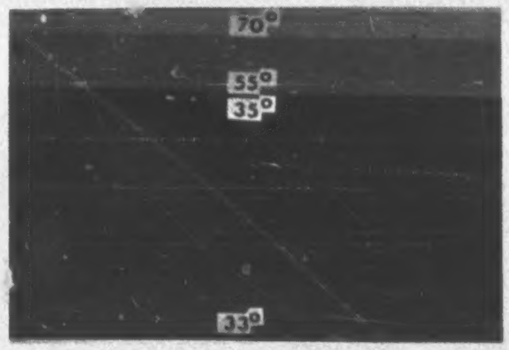
55. While nothing can halt the movement of the sea, the upward flow of chemicals can be stopped by changes in temperatures at different depths of the sea. Temperatures at the top of the sea may change greatly from summer to winter, and from north to south.

56. But in the dark bottom part of the sea, the water is always cold, though never quite freezing.

57. Where this very deep area begins, the temperature is always about 35° above zero, then drops only about two degrees in going down to the ocean floor.



58. Though water heats and cools much more slowly than air, the temperature above the deep dark area may change a great deal.



59. What scientists call a thermocline begins where the light ends and where the sudden change to cold commences. This thermocline is like a wall between the cold waters in the deep sea and the warmer waters nearer the top.

THERMOCLINE

60. But this thermocline, or sharp difference in temperature, is greatest in summer when the sun warms the upper waters of the sea.

THERMOCLINE

61. But in winter ... when the difference in temperature above and below the thermocline starts to disappear ... then the thermocline itself is no longer much of a wall.

62. So it is, that each winter, tons of chemicals, dissolved at the bottom of the sea ...

63. ... sweep up to the surface ...

64. ... and are swept by winds and currents out to distant parts of the sea.

REDUNDANT AUDIO	DIRECTIVE AUDIO
1. A fish moves up in the water ... then down in the water.	1. A fish can move up in the water ... or down in the water.
2. It uses the swim bladder inside itself.	2. Now keep an eye on the swim bladder which the fish has inside itself.
3. When this bladder is large with air, the fish moves up ...	3. Its bladder is full. Now see how the fish moves up.
4. When this bladder changes to a smaller size, the fish moves down.	4. But when its bladder empties, notice how the fish moves down.
5. Watching the fish and sea reminds us that ...	5. Watching the fish and sea reminds us that ...
6. ... our planet's surface is made up of land and water.	6. ... our planet's surface is made up of land and water.
7. The chart tells us that over 70% of this surface is water ...	7. But look at the chart on the screen, and what a large percentage of that surface is water ...

8. ... water like that in the oceans or marine areas of the earth. And watching marine animals among marine plants reminds us that different forms of marine life usually stay where each lives best ...	8. ... In a moment we shall see what different forms of marine life live in this water. Such as animal life and plant life. And each form stays where it lives best.
9. ... often at quite different depths of the sea. Some live at the light green top ... some in the dim blue middle ... and some in the deep black bottom part of the sea. Each depth of the sea has within it many different forms of marine life. All these forms are affected by ...	9. Look closely at this drawing. See how different forms of marine life live at different depths of the sea. Look at each level now. Some forms live at the brightly lit top, some in the dimly lit middle, and others in the deep darkness below. Be sure to remember: there is marine life at each depth of the sea. And all forms are affected by ...
10. ... such changes in the nature of the sea as the winds and tides which we often see along the shore.	10. ... changes in the nature of the sea, such as winds and tides.
11. Where each form of marine life lives ... a fish, for example ... is limited by its need for food.	11. Now listen carefully. Where each form of marine life lives also may be decided by its need for food.
12. Some fish eat plants ... some fish eat animals. Always, one form of marine life eats another form of marine life.	12. Watch how this fish eats plants. See this fish gobble a worm. One form eats another form ...
13. This goes on and on and on.	13. ... on and on and on.
14. If we make a drawing of how this happens, it is like a circle, an endless chain ... a food chain. Such a circle also can represent a pattern of life, a system in the sea: a system of related needs ...	14. Note how this process is like a circle, an endless chain ... a food chain. This chain or circle also can represent a system in the sea: a system of related needs.

15. ... like food and others. One of these other needs is safety. Still another need is light. A fourth important need is warmth. A fish has many needs ... all related to one another, all parts of one system.	15. Learn these four important needs: The first is food. Then there is safety. There is also light. And there is warmth. Remember these needs are all related to one another, all parts of one system.
16. This is called an ecological system.	16. This is called an ecological system.
17. But eco-system is a shorter and easier name for this pattern of life.	17. But eco-system is the short way of saying it. Try to remember this name: eco-system.
18. In this system, the needs of one fish, let us say, will control what it does. Its needs seem to build a fence around its usual place to live.	18. Now watch this brown fish. In its eco-system, its needs control what it does. See how its movements are limited ... how its needs seem to fence it in.
19. Here is an imaginary fish ... as imaginary as our real fish's fence. Our imaginary fish tests the limits, or edges, of that area within which it can find enough food ... yet not too much danger ... enough light or darkness ... yet not too much warmth or cold ... not too much, nor yet too little of whatever it needs.	19. An imaginary fence ... just as imaginary as the fish we want you to watch very closely. See how it tests the limits within which it can find enough food, yet not too much danger ... enough light or darkness ... yet not too much warmth or cold ... not too much, nor yet too little, of whatever it needs.
20. The Law of the Limits is the name we give to what keeps marine life inside such an imaginary fence. This Law of the Limits ...	20. Now memorize this name: The Law of the Limits. That's the name we give to what keeps marine life inside such an imaginary fence. Remember, too, that this law ...
21. ... helps to control where and how each form of marine life lives.	21. ... helps to control where and how each form of marine life lives.
22. In watching different forms of marine life, we learn how the needs of any one form are related to one another within the eco-system.	22. ... and how its needs relate to each other within the eco-system.

23. Think about light in the sea ... sunshine reflected in the water. But the rays from the sun reach only a short distance through the water.	23. Think about light. Most light in the sea comes from the sun. You know how far sunlight travels through space.
24. The colorful, warm rays of the sun reach down only 250 feet into a sea often up to seven miles deep. The cooler rays from the sun light and warm the sea only a few hundred feet more. Below the light green and dim blue levels, the sea is black and cold.	24. Now notice what a short distance it travels through water. Colorful rays come down from the sun into the sea. Now see how the warm yellow, orange and red rays reach only 250 feet into a sea perhaps seven miles deep. Now look at the cooler green, blue and violet rays. They light and warm the sea only a few hundred feet more. But see the difference. Below the brightly lit and dimly lit levels, the sea is dark and cold, perhaps for miles down to the ocean floor.
25. In the eco-system, then, light is related to warmth. Light is also related to safety.	25. Remember, then, in the eco-system, light is related to warmth. Light is also related to safety.
26. Light so colors many forms of marine animals that they look like their surroundings.	26. Pay special attention now to the screen. Notice how light colors marine life to look like its surroundings.
27. Some blend into the light above ... some into the darkness below ...	27. You see how some blend into the light above. Now notice how some blend into the darkness below.
28. ... some resemble the place where they hide ...	28. And watch how closely this one resembles where it is hiding.
29. ... and some, in the deep blackness, flash bright and scary lights.	29. Here's a fish in the deep darkness that can flash lights of its own to see or scare its enemies.
30. In the eco-system, then, light relates to warmth and to safety. Light also relates to food.	30. Taking another look at the eco-system, see how light relates to warmth and to safety. Also to food.

31. Earlier we saw a food-chain ... a food-chain that begins with very small plants. Such plants, many of them in the light green top of the sea, live on the chemicals in the sea which they use to make their food.	31. Earlier we learned that plants start the food-chain. Now listen carefully as we explain how plants themselves are fed. There are chemicals in the sea which plants use to make food.
32. Such marine plants as these have no roots but float on the waves. They soak up chemicals from the sea and make them into food ...	32. Just take a look at the plants without roots which float on the sea. Notice how they soak up chemicals from the sea and make them into food ...
33. ... through a process called photosynthesis. Photosynthesis in the sea needs sunlight to happen at all.	33. ... through a process called photosynthesis. Look at this word and remember it. But never forget: photosynthesis cannot happen in the dark. It needs light. Sunlight.
34. Photosynthesis can happen in millions of tiny plants ... plants too small to see without a microscope ...	34. In such light, photosynthesis can happen in millions of tiny plants. Note how the scientist needs a microscope to see such plants ...
35. ... plants called plankton.	35. ... plants called plankton. Remember the name: plankton.
36. Also called plankton are millions of shrimp-like animals, as tiny as plankton plants.	36. A name also given to millions of shrimp-like animals in the sea. See how this picture is also magnified. Plankton animals are very tiny.
37. These two kinds of plankton ... tiny plants and animals ... begin the food-chain.	37. Keep in mind that these two kinds of plankton ... plankton plants and plankton animals ... begin the food-chain.
38. At the top of the sea ...	38. Think about the top of the sea ...
39. ... marine animals eat plants. At all levels of the sea, marine animals eat each other.	39. Here marine animals eat marine plants. Here also, and at all levels, marine animals eat each other.

40. In the middle part of the sea ... in the dim blue area ...	40. Look at the dimly lit middle area.
41. ... marine animals also search for food. They often eat scraps of dead plants and animals which drift down from above.	41. Watch closely for scraps of dead plants and animals drifting down from above. These also are food ...
42. It is to the bottom of the sea that most of the dead plants and animals drift down through the blackness.	42. ... in the middle and bottom areas of the sea. In a moment you will see what sort of fish eat such garbage at the ocean floor.
43. There they are eaten by very strange marine animals.	43. Compare what these creatures look like with what you have seen at the surface of the sea.
44. What happens at the top of the sea in sunlit areas is related ...	44. Always remember that what happens at the top of the sea is related ...
45. ... to what happens in the darkest areas far below.	45. ... to what happens on the ocean floor.
46. Ooze and clay brought up from the bottom of the sea show signs of dead animals and plants from the top of the sea. In this mud are chemicals from the ocean floor ...	46. Watch how this scientist brings up ooze and clay from the ocean floor. In this mud he finds signs of dead animals and plants, plus chemicals from the bottom of the sea.
47. ... made up of tiny organisms called bacteria. Bacteria live on the dead matter on the ocean floor ...	47. Now listen closely. These chemicals are made by organisms called bacteria. Look at this word: bacteria.
48. ... and make chemicals which dissolve in the dark waters.	48. Watch how the bacteria work under a microscope ... and see the dissolving chemicals in the waters on the ocean floor.
49. These chemicals rise to the top of the sea for plants to use as food during photosynthesis.	49. These dissolved chemicals rise to the top of the sea for plants to use in making food during photosynthesis.

50. So we see how light and warmth, safety and food, all are related to one another within the eco-system.	50. Now review what we have learned: that light and warmth, safety and food, all are related to one another within the eco-system.
51. But we have yet to explain how chemicals from the ocean floor can get to the top of the sea miles above.	51. But we have yet to learn how the chemicals can rise from the ocean floor to miles above at the top of the sea.
52. Warm water at the top of the sea keeps moving away. This makes room for cold water, filled with chemicals, to come up from below to be warmed. There are winds over the seas which help to push warm waters away, making them flow as currents through the waves and tides of the sea.	52. Warm water at the top of the sea keeps moving away. Now watch the direction the arrows are taking. Cold water, filled with chemicals, keeps coming up to replace the warm water which moves away. Note how the winds over the sea help this warm water move away.
53. In the diagram, the reddish lines show how currents flow away from the hot equator toward the cold poles, north and south. There the currents grow cold, sink to the bottom of the sea, then flow back toward the equator along the ocean floor.	53. See how the warm waters are pushed away from the hot equator, flowing away like rivers through the waves and tides of the sea. We call these river currents. Pay close attention as we diagram how they flow away toward the cold poles, north and south. See how the red arrows change in color as the currents grow cold and sink to the bottom of the sea. Now watch them come back toward the equator along the ocean floor.
54. There they rise again and replace the warm waters flowing away from the equator. This diagram shows how the chemicals are swept up in these currents from the ocean floor to the top of the sea.	54. Note how they rise again to replace the warm waters flowing away from the equator. As the arrows show the great circle of currents, watch how the chemicals are swept up from the ocean floor and carried to the top of the sea.

55. This motion of the sea never stops. It goes on and on and on. But temperatures can change the upward flow of chemicals from summer to winter, and from north to south.	55. This motion of the sea goes on and on and on. But remember this: changing temperatures in the sea can also change the upward flow of chemicals from summer to winter, and from north to south.
56. Temperatures at the bottom of the sea never change. Temperatures at the top of the sea do change.	56. Keep this fact up front in your mind: temperatures at the bottom of the sea stay the same. But they change at the top.
57. Where the deep, dark area begins, the temperature is always about 35 degrees above zero. It drops to only about 33 degrees in going all the way down to the ocean floor.	57. Watch the deep dark area on the screen. At its top the temperature is always about 35 degrees above zero. See how little it drops in going down to the ocean floor. Only about two degrees.
58. In the brightly lit and dimly lit areas above this dark area, the temperature changes much, much more. Especially in the warm summer.	58. Compare this dark area with what happens where sunlight reaches. See how the temperature can rise sharply there. For example, from 35 to 55 to 70 degrees.
59. The top of the dark area is the point where a sharp change in temperature may then begin. This point we call a thermocline. The thermocline is like a wall between the warm waters above and the cold waters below.	59. Notice what we call the thermocline: the top of the dark area where the sharp difference in temperature begins. See how the thermocline acts like a wall between the warm waters above and the cold waters below.
60. This wall or thermocline can keep the chemicals from coming up to the top ... especially in summer when the top temperatures are higher.	60. Watch how this wall or thermocline keeps the chemicals from rising ... especially in summer when the top temperatures are higher.
61. But in winter, the temperatures at the top go down. Then the thermocline disappears.	61. Now see how the numbers change ... how the temperatures drop in winter. The difference at the thermocline disappears. The thermocline vanishes.
62. In winter, then, when snowflakes fall, the chemicals from the ocean floor ...	62. Remember, then, that it is in the winter, when snowflakes fall, that the chemicals from the ocean floor ...

63. ... rise up to the surface freely.	63. ... rise up to the surface freely ...
64. There they are swept by winds and currents out to distant parts of the sea.	64. ... and are swept by winds and currents out to distant parts of the sea.

QUESTION-POSING AUDIO	NON-LINEAR AUDIO
1. Have you noticed how a fish can move up in the water ... then down in the water?	1. To rise ... or sink ...
2. It does this by filling or emptying its swim bladder.	2. A fish uses its swim bladder like a balloon ...
3. When this bladder is full of air, the fish can move up in the water.	3. ... filling it ... and rising ...
4. When this bladder starts to empty, which way can the fish move?	4. ... emptying it ... and sinking ...
5. Fish and sea remind us ...	5. ... into the oceans of the earth.
6. ... that our planet earth is mostly covered with water.	6. Earth has many oceans ...
7. If only 30% of the surface of the earth is land, how much is left for water? (PAUSE)	7. ... with water over 70% of its surface.
8. In these marine areas, or seas, are many forms of marine life. You see animal life. Do you see plant life? Marine animals and marine plants ... together are called what? (PAUSE)	8. All marine areas are filled with marine life: animal ... plant.
9. Marine life ... different forms of marine life ... live at different depths of the sea ... each where it lives best. Some near the brightly lit top ... some in the dimly lit middle. Where do the others live? (PAUSE)	9. Each form of marine life has a particular place where it lives best ... different forms at different depths. Some live near the brightly lit top ... some in the dimly lit middle area ... some in the deep darkness below.

10. Because of the nature of the sea ... its winds, tides, and so on ... and because each form of marine life must satisfy its own needs.	10. Each form lives where it lives ... because of the nature of the sea ... and because of its own special needs ...
11. All marine life gets hungry. Would you say, then, that one of its needs is food? (PAUSE) Of course. And each form of marine life needs its own kind of food. Plant or animal.	11. Like finding food ... plant food ... animal food.
12. Have you noticed how one form eats another form?	12. One form eats another form ...
13. Do you see how this goes on and on ...	13. ... on and on and on ...
14. ... like a circle ... and endless chain ... a food-chain? This circle also can represent a system in the sea. What kind of system?	14. ... and endless chain ... a food-chain ... a circle ... a system ...
15. A system of related needs, like food, making marine life live where it lives. What other needs are there? (PAUSE) For one, safety. Safety and what else? (PAUSE) Of course, light. Can we think of a fourth need of marine life? (PAUSE) How about warmth? You see? Many needs, all related to one another, all parts of one system.	15. ... a system of needs, like food ... needs which make marine life live where it lives. Food and safety, too. And light as well. Food and safety, light and warmth. One system of many needs. Each is related to the other, and to the whole.
16. Scientists have a long name for this system ... ecological system. And what's their short name for it?	16. We call this system an ecological system ...
17. (PAUSE) Eco-system. We have seen, then, that ...	17. ... or eco-system ...

18. ... marine life has its own place to live, its own way of fitting into its surroundings, its own needs. Is this true for each form of marine life? (PAUSE) In a way, yes. Because of its needs, each form seems to have a fence around its usual place to live.	18. ... where each form of marine life has its own place to live ... its own way of fitting into its surroundings ... its own needs. Let's think of one fish and how its needs fence it in.
19. A real fence? (PAUSE) No, an imaginary fence, marking the limits to which a fish usually will go. What do we mean by limits? (PAUSE) The edges of an area in which a fish might find enough food ... yet not too much danger ... enough light or darkness ... yet not too much warmth or cold. Not too much, nor yet too little, of whatever it needs. Can you think of a good name for ...	19. An imaginary fence, marking the limits to which it usually will go ... the edges of the area where the fish usually stays. A fish must find enough food ... yet not too much danger ... enough light or darkness ... yet not too much warmth or cold. What makes marine life do what it does to get not too much, nor yet too little, of whatever it needs we call ...
20. (PAUSE) Scientists call it the Law of the Limits.	20. ... The Law of the Limits.
21. How can we learn more about the Law of the Limits and the eco-system?	21. Marine life has an eco-system ... and a Law of the Limits ...
22. (PAUSE) By thinking about how one need of marine life relates to all others.	22. ... and for every form of marine life ... each need is related to all others within its eco-system.
23. Think about light. Where does the sea get most of its light? (PAUSE) From the sun.	23. Think of light ... light from the sun ... reaching a long way through the air, only a short way through the water ...
24. But the colorful rays of the sun do not reach so far through the water as they do through the air. Colorful rays? Yes. Often invisible but in warm and cool colors. The warm rays reach down only 250 feet into a sea up to seven miles deep. How far do the cool rays reach? (PAUSE) They light and warm	24. ... colorful rays from the sun ... warm and cool ... the warm reaching but 250 feet into a sea say seven miles deep ... the cool reaching but a few hundred feet more ... and everything below, dark and cold.

the sea only a few hundred feet more. If we could go down, as in a submarine, down below where the rays of the sun reach, it would be dark ... it would be cold.	
25. Light, then, is related to warmth. In this eco-system, light is also related to safety.	25. Light relates to warmth ... and light relates to safety.
26. In what way? In the way many marine animals are so colored that they look like their surroundings.	26. For light, with color, helps marine animals to hide.
27. Some blend into the light above ... some into the darkness below.	27. Some blend into the light above ... some into the darkness below ...
28. And can you see how some look like the places where they hide?	28. ... some resemble where they hide ...
29. Still others in the deep darkness flash lights of their own. Why? (PAUSE) To see or to scare their enemies.	29. ... and some in the deep darkness flash lights of their own to see or to scare their enemies.
30. Light is related to warmth and to safety. Does it relate also to food?	30. In the eco-system, then, light relates to safety, as it does to warmth. And all three relate to food.
31. Let us see. We have learned that plants start the food-chain in the eco-system. But how are plants themselves fed? (PAUSE) The sea, like the land, has within it the chemicals used by plants to make food.	31. Food and food-chain ... beginning with plants ... which also need food ... food from the chemicals in the sea ...
32. Marine plants, often without roots, and floating on the waves ... soak up these chemicals and make them into food. And what is this process called? (PAUSE)	32. ... soaked up even by floating plants ... and made into food ...

33. Photosynthesis. And can photosynthesis happen in the dark? (PAUSE) No. Photosynthesis happens only when light is present.	33. ... through a process called photosynthesis ... which happens ... only when light is present.
34. But where light and the right chemicals are plentiful, photosynthesis happens in millions of tiny plants. How tiny? (PAUSE) Too small to see without a microscope.	34. Photosynthesis happens in millions of tiny plants ... too small to see without help ...
35. Plants called plankton.	35. ... plants called plankton ...
36. Then are all plankton tiny plants? (PAUSE) Not at all. This same name of plankton is given to millions of tiny shrimp-like animals in the sea ... animals which eat plankton plants.	36. ... also the name of tiny shrimp-like animals, which eat plankton plants.
37. Do these two kinds of plankton, plants and animals, begin the food-chain? (PAUSE) Exactly.	37. In the eco-system, plankton ... plants and animals ... begin the food-chain ...
38. Because of the light and photosynthesis, most marine plants and plant-eating animals, live near the top of the sea.	38. ... in the brightly lit top of the sea ...
39. Do marine animals in this top layer eat anything but plants? (PAUSE)	39. ... where marine animals, like those deeper down ...
40. Like marine animals at all depths, they eat each other.	40. ... also eat each other ...
41. What else might marine animals eat in the lower depths of the sea? (PAUSE) Many eat scraps of dead plants and animals drifting down from above.	41. ... plus whatever dead plants and animals drift down from above.

42. But most of the dead plants and animals, the garbage and debris of the sea, drift down into the deep darkness below.	42. (BLANK)
43. There they are eaten by strange marine animals. Do these also eat each other? (PAUSE) They certainly do.	43. What happens at the ocean floor ...
44. Would you say, then, that what happens at the top of the sea is related to what happens at the bottom? (PAUSE)	44. ... relates to what happens at the top of the sea.
45. Of course it is.	45. (BLANK)
46. Scientists prove this by bringing up mud from the ocean floor in which are signs of dead animals, plants and chemicals. Chemicals? Yes, made by tiny organisms ...	46. There scientists bring up ooze and clay from the mud two miles thick on the ocean floor ... mud with signs of dead animals, plants, and chemicals made by tiny organisms ...
47. ... organisms called bacteria.	47. ... organisms called bacteria.
48. What happens to these chemicals when they dissolve in the waters on the ocean floor? (PAUSE)	48. Chemicals that dissolve ...
49. They rise in the moving waters to the top of the sea where plants use them during photosynthesis.	49. ... and rise to the top of the sea for plants to use as food during photosynthesis.
50. We have learned, then, that light is related to warmth, safety and food in the ecosystem of the sea.	50. Food ... related to warmth, safety and light in the ecosystem of the sea ...
51. But just how can dissolved chemicals get up from the ocean floor miles below into the light far above? (PAUSE)	51. ... food that exists only if dissolved chemicals can come up freely, all the miles from the ocean floor into the light above.

52. Warm waters at the top keep moving away. Cold water from below, full of chemicals, keeps coming up to be warmed. And do the winds help this motion? (PAUSE) Certainly. They help push warm waters away from the hot equator, making them flow like rivers through the waves and tides of the sea.	52. You may wonder how. The sea always moves. Warm water at the top moves away. Cold water from below, full of chemicals, moves up to be warmed. And the winds over the seas ... push warm waters away from the hot equator ... make them flow like rivers through the waves and tides of the sea ...
53. We call these rivers in the sea: currents ... current which flow away from the hot equator toward the cold poles, north and south. And then what happens? (PAUSE) The currents grow cold, sink to the bottom of the sea, and flow back toward the equator along the ocean floor.	53. ... helping them become currents ... currents flowing from the hot equator toward the cold poles, north and south ... there to grow cold, to sink to the bottom of the sea, to flow back toward the equator along the ocean floor ...
54. There they rise and replace the warm waters flowing away from the equator. Is it in this circular motion of currents that chemicals are swept up from the ocean floor to the top of the sea? (PAUSE) Yes. And does this motion of the sea go on constantly? (PAUSE) It does.	54. ... finally to rise again and replace the warm waters still flowing away. A circle ... a great circular motion ... in which chemicals sweep up from the ocean floor to the very top of the sea ... yet a motion that changes ...
55. But changing temperatures in the sea can also change the upward flow of chemicals from summer to winter, and from north to south.	55. ... a circle that is broken ... with changes in water temperatures ... from bottom to top ... from summer to winter ... from north to south.
56. At the bottom of the sea, do temperatures change very much? (PAUSE) No, very little.	56. The bottom of the sea: never freezing yet cold ...
57. Where this dark area begins, the temperature stays about 35 degrees above zero. Does it change in going down to the ocean floor? (PAUSE) Only about two degrees.	57. ... and the top of this dark area always about 35 degrees above zero ... only two degrees less at the ocean floor.

58. But in the sunlit levels above this dark area, the temperature changes a great deal, though water heats and cools more slowly than air.	58. Yet, though water heats and cools more slowly than air, temperatures above the dark area can change a great deal ...
59. Is the thermocline the point where this sharp temperature change begins? (PAUSE) Exactly. At the top of the dark area. The thermocline is like a wall between the warm waters above and the cold waters below ... strongest when the temperatures differ the most.	59. ... and the point where this change begins, at the bottom of the dimly lit area, is a point we call a thermocline ... a wall between ... warm waters above and cold below ...
60. And when is the temperature difference greatest above and below the thermocline? (PAUSE) In summer, when the days are very warm.	60. ... especially in summer. But warm summer days with higher water temperatures ...
61. Does this difference disappear in winter? (PAUSE) Yes. And the thermocline vanishes.	61. ... change to winter, with cooler water temperatures ... and the difference, the wall, the thermocline, disappears.
62. At what time of the year, then, do the chemicals, dissolved at the bottom of the sea ...	62. So in winter ... chemicals from the ocean floor ...
63. ... rise to the surface? (PAUSE) In the winter ...	63. ... move up to the surface ...
64. ... when they are swept out by winds and currents to distant parts of the sea.	64. ... and are swept out with the winds and currents to distant parts of the sea.

APPENDIX B

PERFORMANCE TEST

The correct answers are indicated in the Performance Test by underlining in the case of the multiple-choice items or by the insertion of all the acceptable answers for the constructed responses.

The Knowledge Subtest items were as follows: 1, 2, 3, 4, 6, 8, 9, 10, 12, 16, 19, 20, 21, 27, 28, 31, 34, 36, 38, 40, 43, 44, 45, 47, 49, 51, 55, 58, 62, 63, 64, 65.

The Comprehension Subtest items were as follows: 7, 11, 18, 22, 24, 25, 26, 32, 37, 41, 42, 43, 46, 50, 52, 53, 54, 56, 57, 66.

The Application Subtest items were as follows: 5, 13, 14, 15, 17, 23, 29, 30, 33, 35, 39, 48, 59, 60, 61, 67.

1. The planet earth is covered with _______________ water.

    1) 60%
    2) 65%
    3) 70%
    4) 75%

2. Where in the sea would you expect to find no life?

    1) wherever it is too dark
    2) only where the water is cold
    3) life is everywhere
    4) in places where it is very deep

3. Fish live where they do in the sea because they must

    1) search for chemicals to make food
    2) meet their own special needs
    3) have light for photosynthesis
    4) find warm temperatures

4. Some forms of marine life eat other forms, which are in turn eaten by still other forms. We call this relationship

1) a food chain
2) a circular motion
3) photosynthesis
4) the Law of the Limits

5. If we were to choose a word to describe how our safety is related to light, and light to the warmth of the earth, and those to the food we eat, we might call this pattern a

1) limit
2) chain
3) system
4) circle

6. Each form of marine life

1) eats most plants and animals
2) must be kept warm
3) must have light to grow
4) needs its own kind of food or chemicals

7. As part of the food chain of the sea, a fish is apt to be

1) disobeying the Law of the Limits
2) trapped by fishermen
3) safe among plants
4) eaten by other fish

8. The pattern of needs that makes all animals and plants in our world live where they do is called the eco-system;
ecological system;
law of the limits

9. In the food chain of the sea, plants become food for animals; fish;
plankton animals;
plankton fish

10. It was said in the movie that animals and plants living in the sea have four basic needs, these are:

1) light, chemicals, food, and photosynthesis
2) safety, chemicals, food, and light
3) chemicals, food, warmth, and safety
4) warmth, light, safety, and food

11. What would happen to marine animals if all marine plants were to die?

they would die; they would starve; all would die; there would be no marine animals left

12. A limit is

1) a law
2) the edge of an area
3) a little bit of something
4) the outside of a thing

People don't live under water because of the fact that they have a need for air in order to live. This is an example of the Law of the Limits as it affects human beings. Give two of your own examples of the Law of the Limits at work in the world around us.

13)

14) Accept reasonable applications of the Law of Limits: we need water, warmth, food, etc.; fish can't live on land; we can't live in space; people need food; we need oxygen; we must be safe

15. Imagine that we have found a small, strange creature struggling in a shady pool of water along the shore. It seems quite at home under water. It looks like a fish, yet it has fur. When we pick it up and look at it in the sunlight, it stops struggling and seems comfortable out of the water. In accordance with the Law of the Limits, we might conclude that the creature is a

1) strange kind of fish caught in a tidal pool
2) very young sea bird
3) land mammal lost along the shore
4) sea mammal trapped in a tidal pool

16. When scientists say "eco-system," they mean

1) fish and plants that have similar needs
2) sounds that reflect in patterns
3) only fish and plants that live in the sea
4) all living things have related needs

17. The Law of the Limits

1) determines the position of plants and animals in the food chain
2) applied to all living things
3) determines the number of fish living in the sea
4) applies only to marine life

18. If the earth were surrounded by water instead of air, we would expect ____________________ light to reach us from the sun.

1) a little more
2) much less
3) a little less
4) much more

19. In clear water, the warm rays of the sun penetrate about ____________________ into the sea.

1) 150 feet
2) 850 feet
3) 7 miles
4) 250 feet

20. Which color light ray penetrates deepest into the sea?

blue; violet; blue-violet; dim blue; dark blue;
dark purple; purple; ultra violet (has to be cold color)

21. Most of the sea is

1) dim
2) dark
3) very light
4) light

22. Which of the following best describes the way in which sunlight penetrates the sea?

1) both warm rays and cool rays penetrate all the way to the bottom
2) warm rays penetrate more deeply than cool rays
3) warm rays may be found only near the surface
4) only the cool rays penetrate all the way to the bottom

23. If a fish has a silver-colored belly,

1) enemies below it cannot see it clearly
2) it will look like marine plants
3) enemies above it cannot see it clearly
4) it will stay in the sand on the bottom

24. Animals in the sea have many ways to escape being eaten. One example would be that some

1) eat plants
2) are blind
3) big fish eat only little fish
4) are varied in color

25. Suppose a certain kind of fish is found in only one part of the sea, what might we conclude about its needs?

needs are met there; needs are found there; its needs are in this one area; it needs what is there; it must be there for its food, warmth, light and safety

26. Some fish can luminesce, that is, can produce their own light. Those fish would probably be found

1) where enemies are many
2) near the bottom
3) in the dim part of the sea
4) under rocks

27. Plants use ____________________ to make their food.

1) chemicals
2) bacteria
3) plankton
4) fish

28. The process whereby plants produce sugar in the presence of needed chemicals, water, and light is called photosynthesis.

29. If you were trying to grow sea plants in a tank, and you had correct amounts of light, chemicals, fish, and sea water at the right temperature, you would probably fail because

1) photosynthesis would stop
2) there would be no wind
[✓ 3) there would be no currents]
4) it has to be the right season

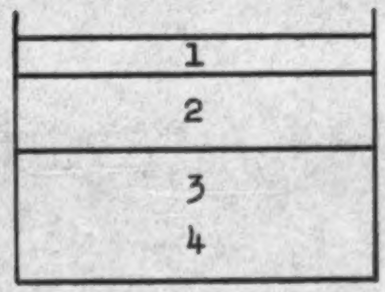
30. In accordance with the Law of the Limits, we will find that moss grows on the shady side of trees in our forests because

1) the temperature is too low on the other side
[✓ 2) it needs less light than most plants]
3) there is more water there
4) there is less wind

31. The food chain in the eco-system of the sea begins with plants
plankton plants

32. In this profile of the sea, which of the numbered areas will contain most plants.

[✓ 1)]
2)
3)
4)



33. The most important difference between plants and animals is that

[✓ 1) plants make their own food]
2) animals can move about
3) animals have legs
4) plants have roots

34. Tiny living organisms found near the surface of the sea are called

1) plankton
2) bacteria
3) fish
4) plants

35. There are fewer animals in the sandy desert than in many other places on earth because

1) it is very hot in the daytime
2) most animals do not like sand
3) few plants grow there that can be eaten
4) there is no place to hide

36. The imaginary fence that keeps marine plants and animals within their own special place is called the Law of Limits.

37. Plants of the sea and grass of the earth are both found near the surface because

1) they both have roots
2) they are safest there
3) they both need chamicals
4) they both need light to make food

38. Plankton is

1) fish
2) plant only
3) animal only
4) both animal and plant

39. We know from the movie that dead animals and plants sink in the sea and become food for the fish that live at the bottom. Briefly, give an example of how what happens at the top of the sea is related to what happens at the bottom.

food comes from the top; food chain; chemicals rise to the top; fish (or plants) that die at the top go to the bottom, are changed to chemicals which rise to the top; plant food comes from the bottom

40. The tiny organisms that assist in the decay of dead plants and animals are found

1) at the thermocline in the sea
[✓ 2) at the bottom of the sea]
3) in the dimly lit area of the sea
4) in parts of the sea with most sunlight

41. We know that animals and plants live where they do because of their different needs; therefore, if they went somewhere else,

1) they could not return
[✓ 2) they would have to change or die]
3) they would have no difficulties
4) it would be uncomfortable but safe

42. Even in its darkest part, the sea is

[✓ 1) in motion]
2) warm
3) full of plants
4) free of chemicals

43. In the deepest parts of the sea, the water temperature

[✓ 1) is always low]
2) changes with the seasons
3) is highest near the equator
4) changes with the weather

44. Most of the warm water in the sea moved toward the

1) thermocline
2) shore
[✓ 3) poles]
4) limit

45. Temperatures at different levels of the sea are

[✓ 1) very different]
2) about the same
3) slightly different
4) exactly the same

46. Which of the following best describes the movement of the sea?

1) cool water moves toward the poles and rises to be warmed
2) the wind cools the sea, and cold water sinks
3) warm water moves toward the poles, sinks, and moves back to be warmed
4) the sea moves up and down with the winds and back and forth with the seasons

47. The rivers of the sea are called ________________.

1) waves
2) currents
3) movements
4) gulfs

48. The warm and cold air in this room are in motion. We have seen that warm and cold currents in the sea are also in motion. Briefly describe how the motion of the air and the sea are alike.

warm air cools and is displaced; they both move in a circle; warm to top, cold to bottom; cold at bottom and warm at top; warm air rises and cool air drops; they both move in currents; move in same direction

49. The chemicals used by plants in photosynthesis come from the

1) sun
2) thermocline
3) land
4) bottom of the sea

50. The sea heats and cools __________________ the air.

1) much faster than
2) faster than
3) the same as
4) slower than

51. At certain times of the year, there is a greater difference in temperature between the lighted surface and the darker depths of the sea than at other times of the year. The level at which the temperature of the sea changes abruptly is known as the

1) Law of the Limits
2) top
3) seasonal current
4) thermocline

52. The difference between the temperature at the surface and the temperature at the bottom of the sea is:

1) greatest in Summer, least in Winter
2) least in Fall, greatest in Spring
3) least in Summer, greatest in Winter
4) greatest in Fall, least in Spring

53. Currents of air, or winds, are very important to life in the sea because winds

1) slow the movement of the sea
2) help form rivers or currents in the sea
3) move debris along the bottom of the sea
4) allow light to reach sea animals

54. The temperature near the surface of the sea is higher than it is deeper down because

1) the bottom of the ocean is always cold
2) light and heat go only so deep
3) there is more movement near the surface
4) currents carry warm water to the surface

55. The temperature near the bottom of the sea is about

1) 33
2) 35
3) 55
4) 70

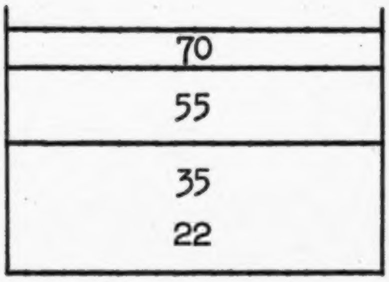
56. Briefly tell how dead marine animals and plants are used in the food chain of the sea:

decayed by bacteria, which produce chemicals, which feed plants; are eaten by other animals (fish) at the bottom; they are changed into chemicals; bacteria make chemicals; they are changed into food; they are eaten as they sink; they are eaten at the bottom

57. Most animals and plants of the sea obey the Law of the Limits and therefore

1) often move from the top to the bottom of the sea
2) hibernate for the season
3) avoid dangerous changes in temperature
4) stay on the bottom of the sea

58. In the profile of the sea shown below, one temperature is in error. Choose the temperature that would correct this error.



1) 35 should be 38
2) 55 should be 60
3) 22 should be 33
4) 70 should be 75

59. On land, warm-blooded animals move freely from relatively low temperatures to relatively high temperatures. Whales, porposes, and turtles are warm-blooded animals, therefore we would expect them to

1) be found only in the warmest parts of the sea
2) remain near the land on the floor of the sea
3) stay as close to warm land as possible
4) be comfortable at most depths in the sea

60. The complex machinery and great care used by men when they go down into the sea shows that

1) the Law of the Limits applies to them too
2) it is difficult to imitate fish
3) the sea is always in motion
4) fish can disobey the Law of the Limits more easily than men

61. On most smoggy days, there is a layer of very warm air over cooler air near the ground. From what you have learned in the movie, you would call this wall between warm and cool air a

1) Law of the Limits
2) system
3) thermocline
4) wave

The four basic needs of animals and plants in the sea are:

62. food ,

63. light ,

64. warmth ,

65. safety .

(In any order)

66. Each plant or animal has its own needs; because of this,

1) each form is usually found in a particular place
2) plants and animals have the same needs
3) plants grow everywhere in the sea
4) fish and plants both need light to live

67. A scientist wishes to use sunlight to light his aquarium, but he wishes to keep the dangerous warm rays of the sun away from the fish who live there. To do this he might

1) shine the sunlight through water to let only the cool rays reach the aquarium
2) put ice in the aquarium to keep the fish cool
3) keep the water in the aquarium from moving
4) change the Law of the Limits

APPENDIX C

SEMANTIC DIFFERENTIAL

Name ______________________________
Last **Middle** **First**

School ______________________________

BE SURE TO MAKE YOUR MARKS HEAVY AND BLACK

ERASE COMPLETELY ANY ANSWERS YOU WISH TO CHANGE

IDENTIFICATION NUMBER

0	1	2	3	4	5	6	7	8	9
0									9
0									9
0	1	2	3	4	5	6	7	8	9

FILL IN SEX **BOY** **GIRL**

THE STORY YOU SAW ABOUT THE ECO-SYSTEM.

U. S. C. CINEMA RESEARCH

GOOD	3	2	1	0	1	2	3	**BAD**
WORK	3	2	1	0	1	2	3	**PLAY**
CRUEL	3	2	1	0	1	2	3	**KIND**
FAST	3	2	1	0	1	2	3	**SLOW**
STRONG	3	2	1	0	1	2	3	**WEAK**
PLEASANT	3	2	1	0	1	2	3	**UNPLEASANT**
REPETITIVE	3	2	1	0	1	2	3	**VARIED**
FEMININE	3	2	1	0	1	2	3	**MASCULINE**
LOUD	3	2	1	0	1	2	3	**SOFT**
ACTIVE	3	2	1	0	1	2	3	**PASSIVE**
HEAVY	3	2	1	0	1	2	3	**LIGHT**